CANYON FUEL COMPANY, LLC
SKYLINE MINE
C/007/005

WASTE ROCK PILE EXPANSION
Deficiency Response

Task ID #2800

August 2007

EXHIBIT 2.3-1

The following pages are excerpts from the Skyline Mine Utah Pollutant Discharge Elimination System (UPDES) permit – Permit No. UT0023540 - Minor Industrial. The pages include a demonstration of a valid permit and the effluent limitations.

The permit is routinely updated. The complete and current permit is maintained on the Mine site, and at the State of Utah, Division of Water Quality, Department of Environmental Quality, Salt Lake City, Utah.

STATE OF UTAH
DIVISION OF WATER QUALITY
DEPARTMENT OF ENVIRONMENTAL QUALITY
SALT LAKE CITY, UTAH

AUTHORIZATION TO DISCHARGE UNDER THE

UTAH POLLUTANT DISCHARGE ELIMINATION SYSTEM
(UPDES)

In compliance with provisions of the Utah *Water Quality Act, Title 19, Chapter 5, Utah Code Annotated ("UCA") 1953, as amended* (the *"Act"*),

CANYON FUEL COMPANY, LLC - SKYLINE MINE

is hereby authorized to discharge from its facility located at approximately seven (7) miles south of Scofield, Utah up Eccles Canyon, with the outfalls located at latitude 39°41 '05 " and longitude 111° 13' 58" for 001, latitude 39°41'05" and longitude 111°09'07" for 002, latitude 39°43'10" and longitude 111°09'15" for 003 to receiving waters named

[redacted]s Creek and UP Canyon Creek

in accordance with discharge points, effluent limitations, monitoring requirements and other conditions set forth herein.

This modified permit shall become effective on June 8, 2007.

This permit and the authorization to discharge shall expire at midnight, November 30, 2009.

Signed this 8th day of June 2007.

Authorized Permitting Official
Executive Secretary
Utah Water Quality Board

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unauthorized location or failing to report an unauthorized discharge may be subject to criminal penalties as provided under the *Act*.

Outfall Number	Location of Discharge Point(s)
001	Outfall from sedimentation pond and mine discharges to Eccles Creek. Latitude 39°41'05", Longitude 111°13'58".
002	Outfall from sedimentation pond at the loadout facility. Discharge is to Eccles Creek. Latitude 39°41'05", Longitude 111°09'07".
003	Outfall from sedimentation pond associated with the waste rock disposal site. Discharge goes to UP Canyon Creek. Latitude 39°43'10", Longitude 111°09'15".

C. Narrative Standard

It shall be unlawful, and a violation of this permit, for the permittee to discharge or place any waste or other substance in such a way as will be or may become offensive such as unnatural deposits, floating debris, oil, scum or other nuisances such as color, odor or taste, or cause conditions which produce undesirable aquatic life or which produce objectionable tastes in edible aquatic organisms; or result in concentrations or combinations of substances which produce undesirable physiological responses in desirable resident fish, or other desirable aquatic life, or undesirable human health effects, as determined by bioassay or other tests performed in accordance with standard procedures.

D. Specific Limitations and Selfmonitoring Requirements

1. Effective immediately and lasting the duration of this permit, permittee is authorized to discharge from Outfalls 001, 002 & 003. Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristics	Discharge Limitations a/ Average 30-Day	Average 7-Day	Daily Maximum	Monitoring Requirements Measurement Frequency	Sample Type
Flow, MGD	NA	NA	NA	Weekly	Measured
Total Iron, mg/L	NA	NA	1.0	2 x Monthly	Grab
Oil & Grease, mg/L b/	NA	NA	10	Weekly	Grab
Total Suspended Solids, mg/L	25	35	70	Weekly	Grab
Total Dissolved Solids, mg/L c/	500	NA	1310	2 x Monthly	Grab
Total Phosphorous, mg/L d/	NA	NA	NA	Quarterly	Grab

The pH shall not be less than 6.5 standard units nor greater than 9.0 standard units in any sample and shall be monitored weekly bya grab sample.

There shall be no visible sheen or floating solids or visible foam in other than trace amounts.

There shall be no discharge of sanitary wastes.

N.A. - Not Applicable.

a/ See Definitions, *Part I.A* for definition of terms.

b/ Oil and grease shall be sampled weekly at 001. At 002 & 003 a visual inspection for oil and grease shall be done at least twice per month. If an oil and grease sheen is observed visually a sample of that effluent shall be taken immediately thereafter and oil and grease shall not exceed 10 mg/L in concentration.

c/ The TDS concentration from each of the outfalls shall not exceed 1310 mg/L as a daily maximum limit. No tons per day loading limit will be applied if the concentration of TDS in the discharge is equal to or less than 500 mg/L as a thirty-day average. However, if the 30-day average concentration exceeds 500 mg/L, then the permittee cannot discharge more than 7.1 tons per day as a sum from all discharge points. Upon determination by the Executive Secretary that the permittee is not able to meet the 500 mg/L 30-day average or the 7.1 tons per day loading limit, the permittee is required to participate in and/or fund a salinity offset project to include TDS offset credits, within six (6) months of the effective date of this permit.

The salinity offset project shall include TDS credits on a ton-for-ton basis for which the permittee is over the 7.1 tons per day loading limit. The tonnage reduction from the offset project must be calculated by a method similar to one used by the NRCS, Colorado River Basin Salinity Control Forum, or other applicable agency.

If the permittee will be participating in the construction and implementation of a salinity offset project, then a project description and implementation schedule shall be submitted to the Executive Secretary within six (6) months of the effective date of the permit, which will then be reviewed for approval. The salinity offset project description and implementation schedule must be approved by the Executive Secretary and shall be appended to this permit.

If the permittee is funding a salinity offset project through third parties, the permittee shall provide satisfactory evidence to the Executive Secretary that the required funds have been deposited to the third party within six (6) months of the effective date of the permit. A monitoring and adjustment plan to track the TDS credits shall also be submitted to the Executive Secretary within six (6) months of the effective date of the permit, which will then be reviewed for approval. The monitoring and adjustment plan must be approved by the Executive Secretary and shall be appended to this permit.

d/ Monthly TP sampling is required for the first year after the effective date of this permit. If after a year of monthly sampling the TP concentrations do not significantly change, the frequency of sampling may be reduced to quarterly events for the remainder of the permit period, pending the permittee petitioning the Executive Secretary to do so. It is the permittee's responsibility to petition the Executive Secretary, who may then approve, partially approve, or deny the request based on results and other available information. If approval is given, the modification will take place without a public notice.

Pages 3-20 through 3-22
are left Intentionally Blank

The plan view of the load-out sediment pond and the pond cross section with detailed construction notes are shown in Map 3.2.1-4. Engineering calculations justifying the 4:1 total slope design are included in Volume 5. The stage volume curve is located in Section 13, Volume 5.

Decant structure and outlet pipe have been modified. The modification is shown on Map 3.2.1-4A.

Rock Disposal Sediment Pond

A sediment pond is located at the west end of the disposal site~~. It will detain surface~~ that treats run-off from a water shed containing approximately 18.7 acres. Prior to an expansion in 2007, approximately 5.81 acres of disturbed area ~~which~~ reported to the sedimentation pond shown on Map 3.2.8-2. Although the disturbed area was expanded in 2007, the effective disturbed area (areas absent of contemporaneous reclamation) is consistently less than approximately three (3) acres. Precipitation from a 10 year, 24 hour rainstorm is expected to be ~~2.43~~ 1.99 inches (NOAA data in Analysis of Sedimentation Pond Capacity Following Waste Rock Expansion - April 2007, Volume 5, Section 15). with a total volume of ~~42,780~~ 35,036 ft^3 (See Table 1 of Analysis of Sedimentation Pond Capacity Following Waste Rock Expansion - April 2007, Section 15, Volume 5).

The combination primary and emergency spillway was designed using a ~~100~~ 10 year, 24 hour rainstorm event (~~Section 2, Vol. 5~~ NOAA data in Analysis of Sedimentation Pond Capacity Following Waste Rock Expansion - April 2007, Volume 5, Section 15). Two rainstorm events were modeled to determine which would have the largest peak runoff. They were the 25 year, 6 hour event with ~~1.85~~ 1.58 inches (~~Section 2, Vol. 5~~ NOAA data in Analysis of Sedimentation Pond Capacity Following Waste Rock Expansion - April 2007, Volume 5, Section 15) and the ~~100~~ 10 year, 24 hour event with ~~3.5~~ 1.99 inches (Section 2, Vol. 5). The peak runoff for the ~~100~~ 10 year, 24 hour and the 25 year, 6 hour rainstorm event were ~~8.62~~11.72 cfs and ~~5.41~~9.22 cfs, respectively.

The hydraulic capacity of the pond (calculated in Analysis of Sedimentation Pond Capacity Following Waste Rock Expansion - April 2007, Volume 5 , Section 15a of M&RP) indicates the pond has the design capacity to contain the runoff from a 10-year, 24-hour precipitation event in

addition to approximately two (2) years of sediment yield. Furthermore, the combined primary and secondary spillways have been designed to convey the peak flow from the 25-year, 6-hour precipitation event that immediately follows the 10-year, 24-hour event. In this scenario, the discharge from the spillway was calculated to be 6.60 cfs at a velocity of 1.3 fps. The pond will also contain runoff from a 100-year, 6-hour precipitation event. This discharge is considered non-erosive, requiring no erosion protection to the embankment.

State Regulation R645-301-746.340 indicates a sediment pond at a refuse site needs to be designed and operated so that at least 90 percent of the water stored during the designed precipitation event will be removed within a 10-day period following the event. In the event that a 10-year, 24-hour precipitation event (1.99 inches) occurs and the level of the water is above the decant pipe after 10 days, the pond will be drained to the level of the decant pipe.

Volume 5, Section 14 provides calculations and designs for drainage control ditches for the Waste Rock site. Analysis of Sedimenation Pond Capacity Following Waste Rock Expansion - April 2007, (Volume 5, Section 15a of MRP) provides a demonstration that the disturbed area ditches are adequately sized to accommodate the pile expansion.

~~The original sediment pond at the NE corner of the site has temporarily been retained as a stock water pond. Only undisturbed drainage will enter the pond and any over-flow will exit via the overflow structure and enter the undisturbed drainage system. (See Sec. 14 Vol 5 for engineering calculations UD-3A). No surface drainage from the disturbed area will enter this pond. If this pond contains water on a regular basis it will be considered to be added as a water monitoring point.~~

The required volume for annual sediment storage has been estimated ~~as 6,906 cubic feet. The combined volumes equal 42,780~~ at 10,330 cubic feet (See Analysis of Sedimentation Pond Capacity Following Waste Rock Expansion - April 2007, Section 15, Volume 5 and Map 3.2.8-4). The 100 percent sediment 'clean-out' marker is the 8-inch decant pipe located in the pond. ~~The original sediment pond on the upper level is not in these calculations.~~ ~~The livestock permittee~~ The landowner representative has requested ~~that this~~ a pond be left as a stock watering pond at reclamation (see Section 4.12).

3.2.2 Overburden and Topsoil Handling

A comprehensive discussion pertaining to this operational component of the mine plan is presented in Section 4.6 - TOPSOIL AND SUBSOIL HANDLING PLAN.

3.2.3 Coal Processing

Maps 3.2.3-1 and 3.2.3-1A are flow diagrams of the entire coal handling system. Designated capacities represent maximum design capabilities necessary to handle surges in the system. The average throughput, a substantially lower figure, is reflected in the annual production schedule.

The plan view of the load-out sediment pond and the pond cross section with detailed construction notes are shown in Map 3.2.1-4. Engineering calculations justifying the 4:1 total slope design are included in Volume 5. The stage volume curve is located in Section 13, Volume 5.

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event that immediately follows the 10-year, 24-hour event. In this scenario, the discharge from the spillway was calculated to be 6.60 cfs at a velocity of 1.3 fps. The pond will also contain runoff from a 100-year, 6-hour precipitation event. This discharge is considered non-erosive, requiring no erosion protection to the embankment.

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Bonding Calculations

Direct Costs		
Subtotal Demolition and Removal	$1,936,268.00	
Subtotal Backfilling and Grading	$941,073.00	
Subtotal Revegetation	$876,537.00	
Direct Costs	$3,753,878.00	
Indirect Costs		
Mob/Demob	$375,388.00	10.0%
Contingency	$187,694.00	5.0%
Engineering Redesign	$93,847.00	2.5%
Main Office Expense	$255,264.00	6.8%
Project Mainagement Fee	$93,847.00	2.5%
Subtotal Indirect Costs	$1,006,040.00	26.8%
Total Cost 2005	$4,759,918.00	
Escalation factor		4
Number of years		0.012
Escalation	$92,823.00	
Reclamation Cost Escalated	$4,852,741.00	
Bond Amount (rounded to nearest $1,000) 2009 Dollars	$5,137,000.00	
Posted Bond September 19, 2006	$5,137,000.00	
Difference Between Cost Estimate and Bond	$0.00	
Percent Difference	0.00%	

	Equipment Cost	Hourly Operating Costs	Equipment Overhead	Operator's Hourly Wage Rate	Hourly Cost	Number of Men or Eq.	Total Eq. & Lab. Costs	Units	Quantity	Units	Production Rate	Units	Equip. + Labor Time/Dis.	Units	Cost
Portal 01															60984
Water Tank 02															7692
Lower Terrace 03															128012
Middle Bench 04															176859
Upper Bench West Fork 05															80398
Southwest Fork 06															75632
Loadout Facilities 07															143364
South Fork Portal Area 08															44873
Waste Rock Disposal 09															218030
Pond Enlargement Interim 10															1204
Pond Diversion DU2 Interim 11															260
Interim Sediment Control 12															2689
Overland Conveyor 13															1076
James Canyon 14															0
Total															941073

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Skyline Mine Waste Rock Disposal 09															
Backfilling and Grading															
CAT 345BL II (10-23)(2nd2005) 2005	15170	66.35	0.1	55.4	223.2	1	223.2	$/HR					4.5	HR	1004
6X4 70,000lbs 12-18 CY (20-11) (2nd2005)	3725	31.25	0.1	43.3	100.96	2	201.92	$/HR					4.5	HR	909
980G Series II EROPS (9-37) (2nd2005)	9635	45.65	0.1	55.4	165.83	1	165.83	$/HR					4.5	HR	746
D6R Series II (9-54) (2nd2005)	7465	33.8	0.1	55.4	139.24	1	139.24	$/HR					4.5	HR	627
Pickup Truck Crew 4x4 1 ton (20-17) (2nd2005)	900	5.4	0.1	0	11.57	1	11.57	$/HR					4.5	HR	52
In Situ Topsoil															
CAT 345BL II (10-23)(2nd2005) 2005	15170	66.35	0.1	55.4	223.2	1	223.2	$/HR					20.9	HR	4665
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Pickup Truck Crew 4x4 1 ton (20-17) (2nd2005)	900	5.4	0.1	0	11.57	1	11.57	$/HR					20.9	HR	242
Topsoil Placement															
6X4 70,000lbs 12-18 CY (20-11) (2nd2005)	3725	31.25	0.1	43.3	100.96	3	302.88	$/HR					279.8	HR	84746
988G EROPS (9-37) (2nd2005) 2005	9010	40.05	0.1	55.4	155.77	1	155.77	$/HR					279.8	HR	43584
14H EROPS (9-11)(2H2005)	8220	34.4	0.1	55.4	144.62	1	144.62	$/HR					279.8	HR	40465
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CLEMENT DRILLING
& GEOPHYSICAL, INC.

4114 West 9950 North
Cedar Hills, Utah 84062
Phone 801-372-3685
Fax 801-785-5748

January 25, 2007, revised July 25, 2007

Mr. Gregg Galecki,
Skyline Mines
HC 35 Box 380
Helper, Utah 84526

Dear Mr. Galecki,

This letter report summarizes the methodology and results of the soil survey conducted by Clement Drilling & Geophysical, Inc. at the Waste Rock site, near Scofield, Utah.

NRCS Soil Data

The Waste Rock site and the surrounding area were evaluated using the United States Department of Agriculture (USDA), Natural Resources Conservation Services' (NRCS) WEB Soil Survey (WSS) utility. Figure 1 & 1a present the map generated by the utility with annotation added showing the approximate location of the soil test pits.

The current NRCS data for the study area has been revised from the data presented in a previous soils report titled *Report of Vegetation and Soils, Proposed Waste Rock Disposal Site, Skyline Mine*, dated November 1981, prepared by Endangered Plant Studies, Inc, Orem, Utah. In the 1981 report the soils on the north-facing mountain slopes were correlated to the Croydon Series. The current NRCS soils data correlates the north-facing mountain slopes to the Pathead Series as presented on Figure1. The Pathead Series was established in 1982 in Carbon County, Utah. The soils correlated to the Trag Series in the 1981 report are still correlated as such in the current data. The official series descriptions for the Pathead and Trag soil series that occur in the study area are presented in Appendix A.

Site Reconnaissance

During the initial site visit to the proposed Waste Rock site the perimeter of the site was hiked and the staked and/or flagged boundaries of the site located. Several traverses of the site were made to determine the number of test pits necessary to represent the site. The soils exposed in several cuts in the hillside on the eastern portion of the site were inspected. The cuts appear to be related to previous logging activities at the site. A cut exposing soils near the southwest edge of the existing waste rock facility was also observed.

Soil Test Pits

Two soil test pits were excavated at the study area on December 8, 2006 at locations that appeared to be representative of each of the two soil series in the study area based on the site

reconnaissance. The locations of the test pits are approximately located on Figure 1 and 1a and coordinates collected using a GPS receiver are presented in the test pit logs. The test pits were excavated by hand to a depth of approximately 1 meter. A propane burner was used to thaw the uppermost, frozen soil to facilitate the excavation of the pits. The pits were logged and photographed. The logs are presented in Appendix B and the photographs in Appendix C. The soils observed in the test pits appear to generally correlate to the NRCS soil series map. The lab analyses of the soil pits are located in Appendix D.

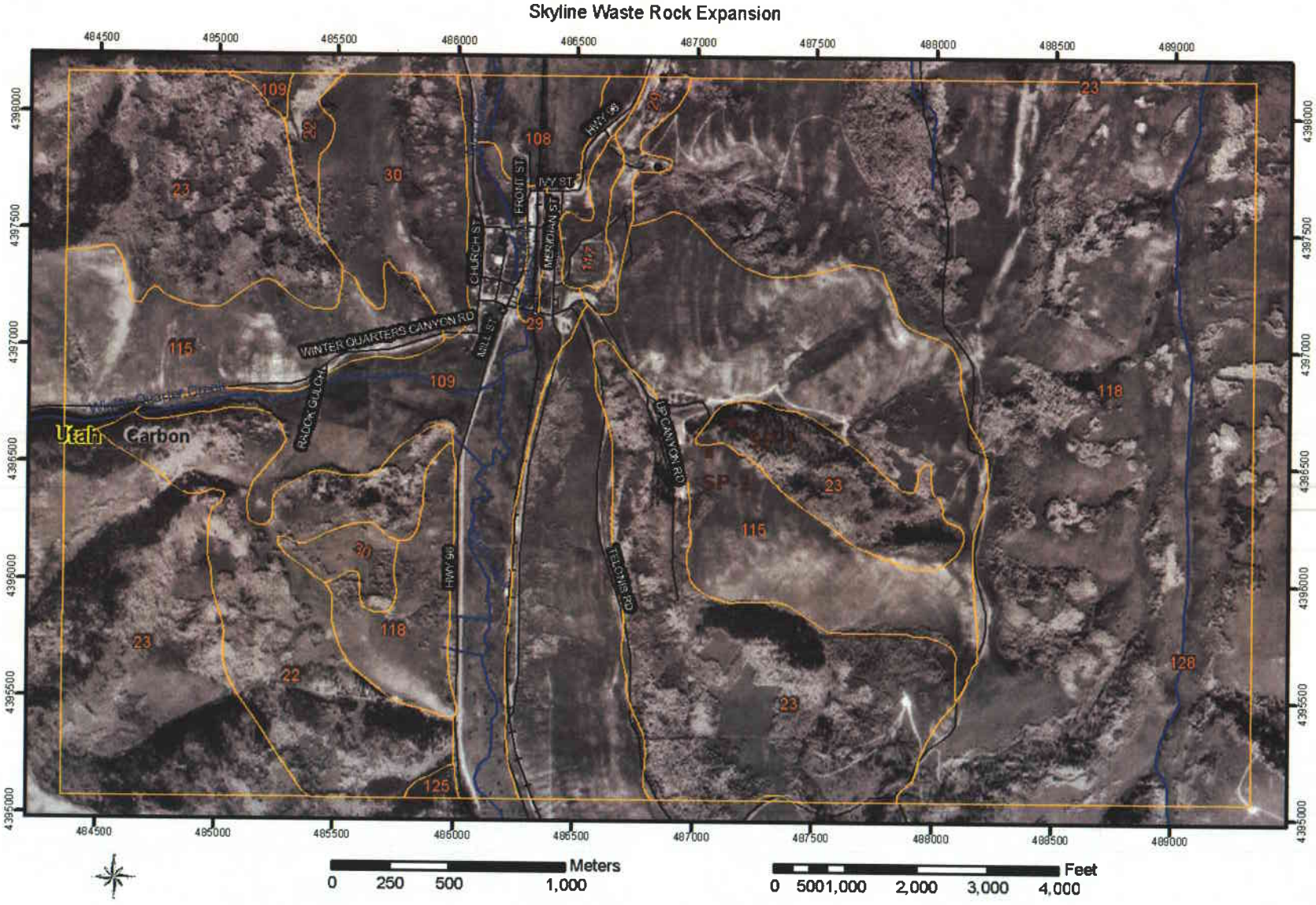
Please feel free to contact me if you have any questions regarding the results of the soil survey. I appreciate the opportunity to work with you on this project.

Sincerely,
Clement Drilling & Geophysical, Inc.

Craig M. Clement

Craig M. Clement, P.G.

Figures



USDA Natural Resources Conservation Service

Web Soil Survey 1.1
National Cooperative Soil Survey

Figure 1
Soil Map and Location of Test Pits

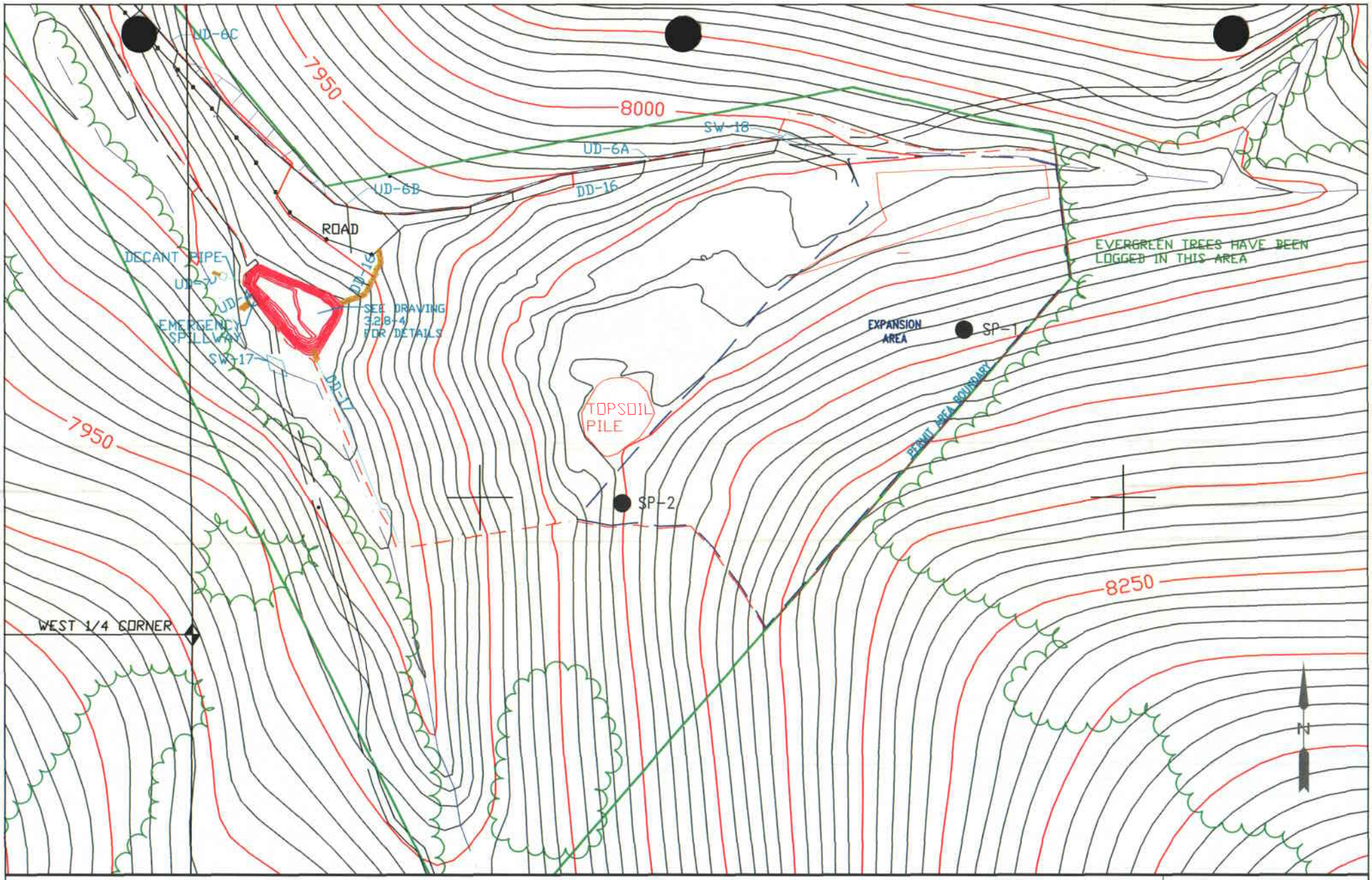

UD-6C
7950
8000
SW-18
UD-6A
UD-6B
DD-16
ROAD
DECANT PIPE
UD-7
UD-8
EMERGENCY SPILLWAY
SW-17
DD-14
SEE DRAWING 328-4 FOR DETAILS
DD-17
EVERGREEN TREES HAVE BEEN LOGGED IN THIS AREA
EXPANSION AREA
SP-1
PERMIT AREA BOUNDARY
TOPSOIL PILE
SP-2
7950
8250
WEST 1/4 CORNER
N
Lease Line
Creek
Fence
Road
Pond
Soil Pit Location
150' 50' 0' 100' 200'

Fig 1a

Skyline Waste Rock Expansion

MAP LEGEND

- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans
- Escarpment, bedrock
- Escarpment, non-bedrock
- Gulley
- Levee
- Slope
- Blowout
- Borrow Pit
- Clay Spot
- Depression, closed
- Eroded Spot
- Gravel Pit
- Gravelly Spot
- Gulley
- Lava Flow
- Landfill
- Marsh or Swamp
- Miscellaneous Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Slide or Slip
- Sinkhole
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Perennial Water
- Wet Spot

SP-1 Location of Test Pits

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 12

Soil Survey Area: Carbon Area, Utah, Parts of Carbon and Emery Counties
Spatial Version of Data: 1
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
9/30/1997; 10/5/1997

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Figure 2
Soil Map Legend

Map Unit Legend Summary

Carbon Area, Utah, Parts of Carbon and Emery Counties

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
22	Croydon loam, 30 to 50 percent slopes	284.0	7.3
23	Curecanti family-Pathead complex	906.2	23.2
29	Dumps,mine	41.3	1.1
30	Falcon-Rock outcrop complex	165.7	4.2
108	Silas loam	56.6	1.4
109	Silas-Brycan loams	322.0	8.2
115	Trag stony loam, 30 to 60 percent slopes	798.5	20.4
117	Trag-Beje-Senchert complex	22.7	0.6
118	Trag-Croydon complex	1,308.5	33.5
125	Uinta-Toze families complex	5.3	0.1
128	Water	0.4	0.0

Figure 3
Soil Map Map Unit Legend

Appendix A
Soil Series Descriptions

LOCATION PATHEAD UT

Established Series
REV: JMD/LDS/SSP
05/1999
PATHEAD SERIES[1]

The Pathead series consists of moderately deep, well drained, moderately permeable soils that formed in slope alluvium and colluvium derived from sandstone and shale. These soils are on benches and mountain slopes. Slopes range from 25 to 80 percent. Average annual precipitation is about 18 inches, and mean annual temperature is about 42 degrees F.

TAXONOMIC CLASS: Loamy-skeletal, mixed, superactive, frigid Typic Haplustepts

TYPICAL PEDON: Pathead extremely stony loam, rangeland. (Colors are for air-dry soil unless otherwise noted.)

A--0 to 3 inches; brown (10YR 5/3) extremely stony loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; common very fine roots; few very fine pores; 5 percent angular gravel, 15 percent cobbles, 40 percent stones, and 5 percent boulders; strongly effervescent; carbonates are disseminated, (13 percent calcium carbonate equivalent); strongly alkaline (pH 8.6); abrupt smooth boundary. (2 to 7 inches thick)

Bw--3 to 14 inches; pale brown (10YR 6/3) very cobbly loam, brown (10YR 5/3) moist; moderate medium subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; common very fine, few fine and medium roots; many very fine pores; 20 percent angular gravel, 15 percent cobbles, and 5 percent stones; strongly effervescent; carbonates are disseminated, (10 percent calcium carbonate equivalent); strongly alkaline (pH 8.8); clear smooth boundary. (3 to 21 inches thick)

Bk--14 to 26 inches; pale brown (10YR 6/3) very cobbly loam, brown (10YR 5/3) moist; moderate medium subangular blocky structure; soft, friable, slightly sticky, and slightly plastic; common very fine, few fine roots; few very fine pores; 20 percent gravel, 25 percent cobbles, and 5 percent stones; strongly effervescent; carbonates are disseminated and segregated as common thin coatings on lower sides of rock fragments, (12 percent calcium carbonate equivalent); strongly alkaline (pH 8.8); clear smooth boundary. (12 to 26 inches thick)

R--26 inches; sandstone.

TYPE LOCATION: Carbon County, Utah; about 2 miles north and 4 miles west of Helper; 1,100 feet north and 400 feet west of the SE corner of sec. 6, T. 13 S., R. 9 E.

RANGE IN CHARACTERISTICS:
Soil moisture: The soil moisture control section is affected by precipitation that falls evenly throughout the year with a significant peak during late summer and early fall.
Depth to lithic contact: 20 to 40 inches to sandstone

Depth to cambic horizon: 2 to 6 inches
Depth to secondary calcium carbonate: 10 to 28 inches

Particle-size control section: 18 to 27 percent clay and 35 to 80 percent rock fragments

A horizon:
Value: 5 or 6 dry, 3 to 5 moist
Chroma: 2 or 3
Calcium carbonate equivalent: 1 to 15 percent
Reaction: slightly alkaline to strongly alkaline

Bw horizon:
Hue: 10YR or 2.5Y
Value: 5 or 6 dry, 4 or 5 moist
Chroma: 2, 3 or 4
Texture: very stony loam, very cobbly loam, very stony fine sandy loam, extremely channery loam, very channery loam, stony loam or gravelly loam
Calcium carbonate equivalent: 1 to 15 percent
Reaction: moderately alkaline or strongly alkaline

Bk or BCk horizon:
Hue: 10YR or 2.5Y
Value: 6 or 7 dry, 3 to 6 moist
Chroma: 2 to 4
Texture: very cobbly loam, extremely cobbly loam, very channery loam, extremely channery loam, extremely stony loam, very stony loam or very stony fine sandy loam, thin strata of gravelly loam or gravelly fine sandy loam are in the upper part of this horizon in some pedons.
Calcium carbonate equivalent: 1 to 15 percent
Reaction: moderately alkaline or strongly alkaline

COMPETING SERIES: These are the Kadygulch, Mowbray, Repkie, Specie, Wilde, and Wilspring series.
Kadygulch, Mowbray, Repkie, and Specie: do not have a lithic contact within 60 inches of the mineral surface.

Wilde: has reaction more acid than pH 7.4.

Wilspring: have soil moisture control sections that are affected by peak precipitation during the spring.

GEOGRAPHIC SETTING:
Parent material: slope alluvium and colluvium derived from sandstone and shale
Landform: benches and mountain slopes
Slopes: 25 to 80 percent
Elevation: 6,600 to 9,400 feet
Mean annual temperature: 38 to 45 degrees F.

Mean annual precipitation: 16 to 22 inches, with a late summer peak
Frost-free period: 60 to 110 days

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Doney, Grobutte, Guben, Rabbitex, and Sheepcan soils. Doney soils are fine-loamy. Grobutte soils lack bedrock within a depth of 40 inches. Guben soils have a mollic epipedon, a calcic horizon, and lack bedrock within 40 inches. Rabbitex soils have a mollic epipedon, a calcic horizon, and are fine-loamy. Sheepcan soils are fine-loamy and lack bedrock within a depth of 40 inches.

DRAINAGE AND PERMEABILITY: Well drained; medium or high runoff; moderate permeability.

USE AND VEGETATION: Used mainly for rangeland and wildlife habitat. Present vegetation is Salina wildrye, black sagebrush, winterfat, bluegrass, pinyon, Utah juniper, curlleaf mountainmahogany, and some poor quality Douglas-fir.

DISTRIBUTION AND EXTENT: Eastern Utah. LRR E, MLRA 47 and 48A.

MLRA OFFICE RESPONSIBLE: Lakewood, Colorado

SERIES ESTABLISHED: Carbon County, Utah, 1982.

REMARKS: Diagnostic horizons and features in this pedon include:

Particle-size control section: The zone from 10 to 26 inches. (Bw and Bk horizons)
Ochric epipedon: The zone from 0 to 3 inches. (A horizon)
Cambic horizon: The zone from 3 to 26 inches. (Bw and Bk horizons)
Secondary calcium carbonate: The zone from 14 to 26 inches. (Bk horizon)
Lithic contact: The contact with sandstone bedrock at 26 inches. (R layer)

The cation exchange activity class was inferred from laboratory data from similar soils in the soil survey area.

The classification was changed from Typic Ustorthent to Typic Haplustept May 1999.

Taxonomic version: Eighth Edition, 1998.

National Cooperative Soil Survey
U.S.A.

[1] http://www2.ftw.nrcs.usda.gov/osd/dat/P/PATHEAD.html - 1-25-07

LOCATION TRAG CO+NM UT
Established Series
Rev. DCM, GB, AP
09/2000
TRAG SERIES[2]

The Trag series consists of very deep, well drained soils that formed in material weathered from granite and schist. Trag soils are on mountains, slopes and fans. Slopes range from 1 to 40 percent. The mean annual precipitation is about 17 inches and the mean annual temperature is about 45 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, frigid Typic Argiustolls

TYPICAL PEDON: Trag sandy loam, rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 9 inches; dark grayish brown (10YR 4/2) sandy loam, very dark brown (10YR 2/2) moist; weak medium subangular blocks parting to moderate fine granular structure; soft, very friable; slightly acid; clear wavy boundary. (4 to 15 inches thick)

BA--9 to 15 inches; brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; weak medium prisms parting to moderate medium subangular blocky structure; hard, firm; thin patchy clay films; neutral; clear wavy boundary. (0 to 12 inches thick)

Bt--15 to 35 inches; brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) moist; moderate medium prisms parting to moderate medium subangular blocky structure; very hard, firm; thin nearly continuous clay films; neutral; clear smooth boundary. (16 to 34 inches thick)

C--35 to 60 inches; brown (7.5YR 5/4) sandy clay loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; very hard, friable; neutral.

TYPE LOCATION: Larimer County, Colorado; 2,350 feet east and 600 feet south of the NW corner of Sec. 10, T. 7 N., R. 71 W.

RANGE IN CHARACTERISTICS:
Soil moisture: Ustic moisture regime.
Peak precipitation coming during the months of March through June.
Mean annual soil temperature: 45 to 47 degrees F
Mean summer soil temperature: 59 to 60 degrees F
Depth to secondary calcium carbonate: 40 or more inches
Particle-size control section (weighted average):
Clay content: 18 to 35 percent
Sand content: 30 to 65 percent
Rock fragments: 0 to 30 percent by volume
A horizon:
Hues: 7.5YR or 10YR
Value: 3 through 5 dry, 2 or 3 moist

Chroma: 2 or 3
Base saturation: 75 to 100 percent
Reaction: slightly acid to mildly akaline

BA horizon (if present):
Hues: 7.5YR or 10YR
Value: 3 through 6 dry, 2 through 6 moist
Chroma: 2 through 4
Texture: clay loam, sandy clay loam, sandy loam, loam
Reaction: slightly acid to mildly alkaline

Bt horizon(s):
Hues: 7.5YR or 10YR
Value: 4 through 6 dry, 3 through 5 moist
Chroma: 2 through 6
Texture: clay loam, sandy clay loam, loam, silty clay loam
Clay content: 18 to 35 percent
Reaction: neutral to mildly alkaline
Bridging of clay between sand grains and clay films exist on vertical ped faces and in pores.

C horizon (if present):
Hues: 7.5YR or 10YR
Texture: clay loam, sandy clay loam, loam
Base saturation: 90 to 100 percent
Reaction: neutral to moderately alkaline

COMPETING SERIES: Absarook - calcium carbonate above 40 inches depth
Archmesa - moderately deep to bedrock
Bielenberg - deep to bedrock
Burtoner - moderately deep to bedrock
Clancy - moderately deep to bedrock
Clasoil - have hues as yellow as 2.5Y
Dooley - calcium carbonate above 40 inches depth
Doughty - calcium carbonate above 40 inches depth
Empedrado - calcium carbonate above 40 inches depth
Fairfield - calcium carbonate above 40 inches depth
Farnuf - calcium carbonate above 40 inches depth
Farside - lower elevations and more northernly latitudes
Felor - calcium carbonate above 40 inches depth
Greenway - calcium carbonate above 40 inches depth
Gurney - moderately deep to bedrock
Hangdo - formed in eolian material over alluvium
Hoppers - moderately deep to bedrock
Hyalite - lithologic discontinuity in Bt
Jeffcity - moderately deep to bedrock
Kokoruda - forested soil with O horizon

Livona - calcium carbonate above 40 inches depth
Martinsdale - calcium carbonate above 40 inches depth
Maudlin - moderately deep to bedrock
Meagher - calcium carbonate above 40 inches depth
Moen - moderately deep to bedrock
Moento - moderately deep to bedrock
Pianohill - moderately deep to bedrock
Placerton - moderately deep to bedrock
Reeder - moderately deep to bedrock
Reedwest - modrately deep to bedrock
Snakejohn - deep to bedrock
Tragmon - formed sandstone and shale parent material
Trazuni - redox features in the lower part
Ulrant - deep to bedrock
Vida - calcium carbonate above 40 inches depth
Watne - calcium carbonate above 40 inches depth
Watrous - moderately deep to bedrock
Williams - calcium carbonate above 40 inches depth
Yegen - calcium carbonate above 40 inches depth

GEOGRAPHIC SETTING: Trag soils are on mountain slopes and fans. Slopes range from 1 to 40 percent. The soil formed in material weathered from granite and schist that has been locally transported in places. Elevation ranges from 6,800 to 8,900 feet. The soils are in a cool semiarid climate with annual precipitation ranging from 15 to 22 inches. The mean annual temperature is 43 to 46 degrees F. The frost- free season is about 65 to 100 days. In New Mexico, precipitation ranges to 22 inches with air temperatures down to 40 degrees F. and frost-free periods up to 110 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Boyle, Bruce, Ratake, and Wetmore soils and the competing Farnuf and Moen soils. Boyle, Ratake and Wetmore soils have bedrock at depths of less than 20 inches. Bruce soils are coarse-loamy.

DRAINAGE AND PERMEABILITY: Well drained; medium to rapid runoff; moderate to moderately slow permeability.

USE AND VEGETATION: The soils are used for rangeland. Native vegetation is mainly blue grama, big and little bluestem, junegrass, some forbs and shrubs, and widely spaced ponderosa pine.

DISTRIBUTION AND EXTENT: Mountainous parts of Northern and central Colorado, eastern Utah, and central New Mexico. The series is of small extent.

MLRA OFFICE RESPONSIBLE: Lakewood, Colorado

SERIES ESTABLISHED: Larimer County, Colorado, 1975. The name is a coined name.

REMARKS: This soil has:
Mollic Epipedon: The zone from 0 to 15 inches
Argillic Horizon: The zone from 15 to 35 inches
Prior to 2/1999 OSD update the classification was a Typic Argiboroll, fine-loamy, mixed. The 2/1999 update reclassified this series to a Pachic Argiustoll, fine-loamy, mixed, superactive, frigid. Historically this series concept was not pachic. Therefore, in this update a one inch reduction in the thickness of the mollic epipedon was incorporated and adjustment to the range in characteristics to maintain the series concept as typic.

Taxanomic Version: Eighth Edition, 1998

National Cooperative Soil Survey
U.S.A.

[2] http://www2.ftw.nrcs.usda.gov/osd/dat/T/TRAG.html - 1-25-07

Appendix B

Soil Test Pit Logs

Site	SP-1	Skyline Mine Waste Rock Expansion											
Name	Craig Clement					Drainage	WD	Well Drained					
Date	12/8/2006					Flooding	none						
Weather	Clear, 5°F					Ponding	none						
Location	N 39°43'11.935", W 111°8'58.731"					Depth to Water Table	245 ft	estimated					
Datum	NAD 83					Earth Cover	TOC	Mixed aspen and conifer					
Topographic Map	Scofield, UT; 1:24,000; 1997					Parent Material	COL	colluvium					
Slope Aspect	NNW					Bedrock, Kind	SST, SIS, SHA	Interbedded sandstone, siltstone and shale					
Slope Gradient	80%					Bedrock, Fracture	-						
Slope Complexity	Complex					Bedrock, Hardness	MO	Moderate					
Slope Shape	LV	Linear, Convex				Bedrock, Depth	200 cm	estimated based on outcrops observed in nearby disturbed areas					
Hillslope Profile Postion	BS	backslope				Erosion, Kind	G	gully					
Geomorphic Component	SS	side slope				Erosion, Degree	1	>0 up to 25%					
Microrelief	MH	microhigh				Runoff	VH	Very High					
Drainage Pattern	dendritic					Surface Fragments	Stony						

Diagnostic Horizons	Observation Method	Depth (cm)		Boundary		Color (moist)		Texture	Structure	Reaction (HCl)	% Rock Fragments & Size	% Roots, Size & Location
		From	To	Distinctness	Topography							
A	SP	0	23	Gradual	Wavy	Brownish black	5YR 2/1	L to SIL w/ trace FS	1,VF,GR	VE	10%,GR to CB	15%, VF to C, T
B	SP	23	36	Gradual	Wavy	Moderate yellowish brown	10YR 5/4	SI, trace FS	1,VF,GR	VE	5%,GR to CB	5%,VF to M, T
BC	SP	36	46	Gradual	Wavy	Pale yellowish orange	10YR 8/6	FS	1,VF,GR	VE	10%,GR to CB	<2%,VF
C	SP	46	97	Gradual	Wavy	Grayish orange	10YR 7/4	SIC	1,VF,GR	VE	10%,GR to B	<2%,VF
Penetration with pick became very difficult												

Depth (cm)		Description
From	To	
0	23	Loam to silty loam with trace fine sand
23	36	Silt with trace fine sand, moderate amount of root material
36	46	Fine sand with minor amount of root material, moist
46	97	Clayey silt with sandstone clasts (up to ~ 30 cm in length, minor amount of root material, moist, some Fe staining along root traces.

Site **SP-2** Skyline **Mine Waste** Rock Expansion

Name	Craig Clement	**Drainage**	WD	Well Drained	
Date	12/8/2006	**Flooding**	none		
Weather	Clear, 5°F	**Ponding**	none		
Location	N 39°43'9.294", W 111°9'5.541"	**Depth to Water Table**	245 ft	estimated	
Datum	NAD 83	**Earth Cover**	SOS	Other shrub cover, primarily sagebrush	
Topographic Map	Scofield, UT; 1:24,000; 1997	**Parent Material**	COL	colluvium	
Slope Aspect	W	**Bedrock, Kind**	SST, SIS, SHA	Interbedded sandstone, siltstone and shale	
Slope Gradient	80%	**Bedrock, Fracture**	-		
Slope Complexity	Complex	**Bedrock, Hardness**	MO	Moderate	
Slope Shape	LV Linear, Convex	**Bedrock, Depth**	200 cm	estimated based on cut at existing waste rock site	
Hillslope Profile Postion	BS backslope	**Erosion, Kind**	G	gully	
Geomorphic Component	SS side slope	**Erosion, Degree**	1	>0 up to 25%	
Microrelief	ML microlow	**Runoff**	VH	Very High	
Drainage Pattern	dendritic	**Surface Fragments**	Stony		

Diagnostic Horizons	**Observation Method**	**Depth (cm)** From	To	**Boundary** Distinctness	Topography	**Color (moist)**		**Texture**	**Structure**	**Reaction (HCl)**	**% Rock Fragments & Size**	**% Roots, Size & Location**
A	SP	0	25	Gradual	Wavy	Moderate yellowish brown	10YR 5/4	SIC	1,VF,GR	VE	20%,GR to CB	5%, VF to M, T
B	SP	25	58	Gradual	Wavy	Dark yellowish orange	10YR 6/6	SIC w/ trace FS	1,VF,GR	VE	20%,GR to CB	2%,VF to M, T
BC	SP	58	97	Gradual	Wavy	Dark yellowish orange	10YR 6/6	SIC	1,VF,GR	VE	20%,GR to CB	<2%,VF

Penetration with pick became very difficult

Depth (cm) From	To	**Description**
0	25	Clayey silt with root material, sandstone clasts (up to ~ 20 cm in length), moist to frozen
25	58	Silt with clay and trace fine sand, some root material, Fe staining primarily around sandstone clasts (up to ~ 20 cm in length), moist
58	97	Clayey silt with little to no root material, abundant sandstone clasts (up to 15 cm in length) clasts are gray to rust colored, moist

Appendix C

Soil Test Pit Photographs

SP-1 Photograph 1
Looking SSE at Test Pit

SP-1 Photograph 2
Test Pit SP-1

SP-1 Photograph 3
Approximately 0" to 17"

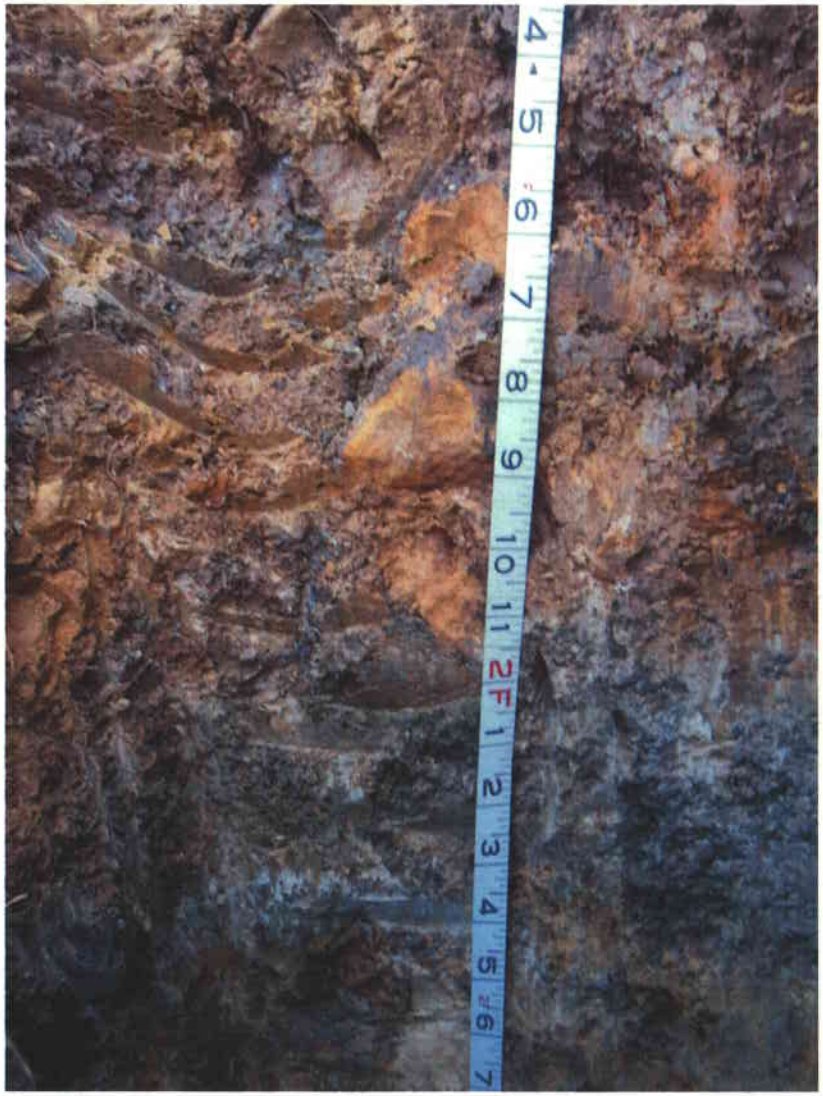
SP-1 Photograph 4
Approximately 12" to 33"

SP-1 Photograph 5
Approximately 24" to 38"

SP-1 Photograph 6
Closeup of Fe staining and Sandstone Clast

SP-2 Photograph 1
Looking E at Test Pit SP-2

SP-2 Photograph 2
Approximately 0" to 18"



SP-2 Photograph 3
Approximately 16" to 30"

SP-2 Photograph 4
Approximately 22" to 38"

Appendix D

Lab Analysis

Inter-Mountain Laboratories, Inc.
1673 Terra Avenue, Sheridan, Wyoming 82801
(307) 672-8945

Soil Analysis Report

Canyon Fuel Company, LLC.

HCR 35, Box 380
Helper, UT 84526

Report ID: S0707529001

Date: 8/24/2007

Work Order: S0707529

Project: Skyline Utah#6

Date Received: 7/30/2007

Lab ID	Sample ID	Depths cm	pH s.u.	Saturation %	Electrical Conductivity dS/m	Field Capacity %	Wilt Point %
S0707529-001	SP-1A	0-23	6.6	104	0.38	29	21
S0707529-002	SP-1B	23-36	6.4	27.1	0.22	16	11
S0707529-003	SP-1BC	36-46	6.5	35.7	0.20	19	15
S0707529-004	SP-1C	46-97	6.7	34.5	0.19	17	13
S0707529-005	SP-2A	0-25	6.7	44.0	0.41	17	12
S0707529-006	SP-2B	25-58	6.7	38.3	0.26	19	15
S0707529-007	SP-2C	58-97	6.9	32.9	0.22	16	12

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor

Karen Secor, Soil Lab Supervisor

Inter-Mountain Laboratories, Inc.
1673 Terra Avenue, Sheridan, Wyoming 82801
(307) 672-8945

Soil Analysis Report
Canyon Fuel Company, LLC.
HCR 35, Box 380
Helper, UT 84526

Report ID: S0707529001
Date: 8/24/2007
Work Order: S0707529

Project: Skyline Utah#6
Date Received: 7/30/2007

Lab ID	Sample ID	Depths cm	Calcium meq/L	Magnesium meq/L	Sodium meq/L	Potassium meq/L	SAR	Available Sodium meq/100g	Exchangeable Sodium meq/100g
S0707529-001	SP-1A	0-23	2.72	0.82	0.11	0.55	0.09	0.03	0.02
S0707529-002	SP-1B	23-36	1.22	1.13	0.19	0.29	0.17	0.02	0.02
S0707529-003	SP-1BC	36-46	0.84	0.75	0.24	0.22	0.26	0.03	0.03
S0707529-004	SP-1C	46-97	0.83	0.67	0.18	0.20	0.20	0.04	0.03
S0707529-005	SP-2A	0-25	2.75	1.09	0.12	0.64	0.09	0.02	0.02
S0707529-006	SP-2B	25-58	1.63	0.65	0.15	0.11	0.14	0.04	0.03
S0707529-007	SP-2C	58-97	1.20	0.82	0.23	0.07	0.23	0.04	0.03

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor
Karen Secor, Soil Lab Supervisor

Inter-Mountain Laboratories, Inc.
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Canyon Fuel Company, LLC.
HCR 35, Box 380
Helper, UT 84526

Report ID: S0707529001

Project: Skyline Utah#6
Date Received: 7/30/2007

Date: 8/24/2007
Work Order: S0707529

Lab ID	Sample ID	Depths cm	Sand %	Silt %	Clay %	Texture	Coarse Fragment %
S0707529-001	SP-1A	0-23	49.0	43.0	8.0	Loam	2.43
S0707529-002	SP-1B	23-36	29.0	50.0	21.0	Silt Loam	0.77
S0707529-003	SP-1BC	36-46	19.0	49.0	32.0	Silty Clay Loam	1.22
S0707529-004	SP-1C	46-97	35.0	39.0	26.0	Loam	1.34
S0707529-005	SP-2A	0-25	41.0	36.0	23.0	Loam	0.50
S0707529-006	SP-2B	25-58	18.0	47.0	35.0	Silty Clay Loam	0.34
S0707529-007	SP-2C	58-97	27.0	45.0	28.0	Clay Loam	0.10

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor
Karen Secor, Soil Lab Supervisor

Inter-Mountain Laboratories, Inc.
1673 Terra Avenue, Sheri[illegible] Wyoming 82801
(307) 672-8945

Soil Analysis Report

Canyon Fuel Company, LLC.

HCR 35, Box 380
Helper, UT 84526

Report ID: S0707529001

Project: Skyline Utah#6

Date Received: 7/30/2007

Date: 8/24/2007

Work Order: S0707529

Lab ID	Sample ID	Depths	Boron	TKN	Nitrogen Nitrate	Phosphorus	Selenium
		cm	ppm	%	ppm	ppm	ppm
S0707529-001	SP-1A	0-23	0.82	0.29	6.99	9.60	<0.02
S0707529-002	SP-1B	23-36	0.16	0.01	0.08	7.63	<0.02
S0707529-003	SP-1BC	36-46	0.23	0.02	0.11	7.28	<0.02
S0707529-004	SP-1C	46-97	0.21	0.01	2.30	4.20	<0.02
S0707529-005	SP-2A	0-25	0.34	0.08	3.37	8.89	<0.02
S0707529-006	SP-2B	25-58	0.38	0.03	0.08	2.53	<0.02
S0707529-007	SP-2C	58-97	0.27	0.01	0.14	3.96	<0.02

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
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Lab ID	Sample ID	Depths cm	Total Carbon %	TOC %	Total Sulfur %	T.S. AB t/1000t	Neut. Pot. t/1000t	T.S. ABP t/1000t
S0707529-001	SP-1A	0-23	10.2	10.0	0.05	1.41	10.2	8.80
S0707529-002	SP-1B	23-36	0.5	0.4	0.01	0.36	3.91	3.55
S0707529-003	SP-1BC	36-46	0.4	0.4	<0.01	<0.01	0.21	0.21
S0707529-004	SP-1C	46-97	0.3	0.2	0.04	1.19	5.70	4.51
S0707529-005	SP-2A	0-25	2.0	2.0	0.01	0.38	2.06	1.68
S0707529-006	SP-2B	25-58	0.6	0.6	<0.01	<0.01	6.99	6.99
S0707529-007	SP-2C	58-97	0.3	0.2	<0.01	<0.01	6.37	6.37

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor
Karen Secor, Soil Lab Supervisor

CRAIG M. CLEMENT, P.G.

GEOLOGIST

Education

BS, Geology, Brigham Young University, 1994

Professional Registrations

Professional Geologist: Wyoming #PG-3460, 2002; Utah #5263617-2250, 2003

Continuing Education

40-hr OSHA HAZWOPER: 1997

8-hr OSHA HAZWOPER Refresher: 2002

MS Degree Coursework in Hydrogeology/ Geophysics

Mine Safety Training Administration Part 48 (24-hr) New Miner Training: August 2005

I have over thirteen years of experience as a geologist/ environmental scientist and have worked on projects fifteen states. Responsibilities have included utilizing various geophysical methods to provide information regarding subsurface conditions and properties. I have experience with geophysical methods including well logs, seismic SASW and refraction, ground penetrating radar and electrical resistivity. Projects I have worked on also include Environmental Impact Statements, risk assessments (used to evaluate threats to human health and the environment); preparation of air, surface water and groundwater discharge permit applications; and compliance monitoring associated with the resultant permits. I have assisted with mining related permitting including evaluating impacts to soil, groundwater and surface waste resources. I am proficient with Trimble GPS equipment, including data loggers and software for differential correction, and am familiar with Geographic Information System (GIS) database management and ESRI ArcGIS software.

GEOLOGIC / GEOPHYSICAL RECONNAISSANCE AND MAPPING

- ***Wind Turbine Geotechnical Investigations: Abilene, Texas, Idaho Falls, Idaho and Judith Gap, Montana.*** *Project Geologist.* Conducted down-hole seismic shear wave surveys and spectral analysis of surface waves (SASW) surveys to determine shear and compression wave velocities for wind turbine foundation design using a Geometrics SmartSeis S12 seismograph. Projects included investigating more than 175 turbine locations. Collected and interpreted seismic data and calculated the bulk modulus, shear modulus, Poisson's ratio and Young's modulus of the subsurface materials.

- ***Proposed Housing Development Fault Mapping: Jackson Hole, Wyoming.*** *Project Geologist.* Conducted bedrock mapping to establish fault locations at the proposed Elk Dance Estates using Geometrics SmartSeis S12 seismograph and seismic refraction modeling software. Collected and interpreted seismic data and developed cross-sections for determining fault locations.

- ***Jim Bridger Power Plant Ash Pond Expansion Bedrock Mapping: Sweetwater County, Wyoming.*** *Project Geologist.* Conducted bedrock mapping to establish depth to bedrock and bedrock velocities using Geometrics SmartSeis S12 seismograph and seismic refraction modeling software. Collected and interpreted seismic data and developed cross-sections for determining bedrock characteristics.

- ***Montana and Wyoming Departments of Transportation Projects Bedrock Mapping: Montana and Wyoming.*** *Project Geologist.* Projects included Bigfork North and South, U.S. Highway 93 North, Clearwater Junction, Carbon County Line and I-90 slope failures near Sheridan, WY. Conducted bedrock mapping using Geometrics SmartSeis 512 seismograph and seismic refraction modeling software. Collected and interpreted seismic data and developed cross-sections for determining depth to bedrock and bedrock rippability.

- ***CENEX and ConocoPhillips Refinery Cross-Hole Hear Wave Seismic Surveys: Laurel and Billings, Montana.*** *Project Geologist.* Conducted cross-hole seismic surveys to determine shear and compression wave velocities for process equipment foundation design using a Geometrics SmartSeis S12 seismograph, a triaxial borehole geophone and a Ballard Borehole Seismic Source. Collected and interpreted seismic data and calculated the bulk modulus, shear modulus, Poisson's ratio and Young's modulus of the subsurface materials.

NATURAL RESOURCE DEVELOPMENT

- ***Garfield Wetlands Monitoring, Kennecott Utah Copper: Magna, Utah.*** *Project Geologist.* Assisted Kennecott in developing monitoring protocols for sampling water, soil and macroinvertabrates in the North End Wetland Mitigation Area. Monitoring was performed under an agreement with the U.S. Environmental Protection Agency (EPA) in order to evaluate potential impacts of metals in the wetlands to avian species. Conducted monitoring and assisted Kennecott with report presentation and representation to meetings with the Technical Resource Committee and representatives from EPA, U.S. Fish and Wildlife Service, Utah Department of Environmental Quality, Friends of the Great Salt Lake and the local community.

- ***BLM Black Butte Pit 14 Coal Lease-by-Application Environmental Impact Statement (EIS): Paonia, Colorado.*** *Project Scientist.* Responsible for preparing the Soil, SurfaceWater and Graoundwater Resources sections of the EIS and assessing impacts of mining-related impacts on soil and water resources.

- ***USDA-Forest Service Dry Fork Coal Lease-by-Application Environmental Impact Statement (EIS): Paonia, Colorado.*** *Project Scientist.* Responsible for preparing the Water Resources sections of the EIS and assessing impacts of mining-related subsidence on water resources.

- ***Bureau of Land Management (BLM) Pocatello Resource Management Plan (RMP): Southeastern Idaho.*** *Project Scientist.* Prepared sections of the RMP related to soils and geology. Evaluated soil types in the Pocatello District and potential impacts to soil quality through activities conducted on BLM-administered lands.

- ***BLM Utah Fire Management Plan Environmental Assessments (EAs) and Land Use Plan Amendments EA: Utah.*** *Project Scientist.* Prepared sections of the RMP related to soils and geology. Coordinated with BLM resource specialists across the state of Utah to obtain information necessary for the Affected Environment and Environmental Consequence sections of the documents.

- ***Dubois Fish Rearing Station Groundwater Supply Evaluation: Dubois, Wyoming.*** *Project Geologist.* Evaluated potential groundwater sources not influenced by surface water, recommended drilling locations and designed test and production wells. Conducted on-site oversight of drilling and well completion. Conducted well performance testing. Project resulted in two flowing artesian wells to supply fish hatchery needs.

- ***Underground Mining Impacts on Surface Water Sources: Sevier County, Utah.*** *Project Geologist.* Conducted gain/loss studies to characterize effects on perennial streams of proposed long-wall mining activity at the Box Canyon Tract of SUFCO Mine. The project involved stream gauging and water quality monitoring to evaluate potential impacts of underground mining on the west and east forks of Box Canyon Creek.

WATER RESOURCE INVESTIGATION

- ***Bear Claw Ranch Groundwater Study Evaluation: Sheridan County, Wyoming.*** *Staff Geologist.* Conducted an evaluation of a regional geologic and hydrogeologic setting. Developed alternatives for supplying groundwater to meet ranch water supply requirements.

- ***Coal Lease Area Seep and Spring Survey: Scofield, Utah.*** *Project Geologist.* Conducted a seep and spring survey as part of baseline data collection for a proposed coal lease area. Located all seeps and springs in the 12-square mile lease area, and collected water quality data at each site. Mapped the sites using GPS coordinates. Baseline data was incorporated into an environmental impact study.

GEOGRAPHIC INFORMATION SYSTEMS SERVICES

- ***Seminoe and Pioneer Pipe Lines Geotechnical Survey: Utah and Wyoming.*** *Project Geologist.* Conducted a geotechnical survey of over 600 miles of pipeline to identify areas of potential instability, pipeline exposures due to erosion and other threats to pipeline integrity. Compiled data in a GIS database with geologic and topographic information to identify areas requiring field inspections. Results of the field inspections were recorded and located using GPS equipment and added to the GIS database. Areas of concern were ranked based on potential threat to the pipeline.

- ***Boy Scouts of America Camp GPS Mapping: Summit County, Utah.*** *Project Geologist.* Mapped new and existing camp facilities (using GPS equipment) at Bear West Company Boy Scouts of America Camp Steiner. Compiled existing base map information mapped features, aerial photography and U.S. Geological Survey (USGS) topographic maps into GIS database. Produced maps for environmental assessment scoping document and public meeting presentation.

- ***Pioneer Pipe Line GPS Mapping: Utah and Wyoming.*** *Project Geologist.* Conducted helicopter-borne GPS mapping of potential routes for the Pioneer Pipe Line, and evaluated potential slope instabilities along the proposed route.

ABANDONED MINE RECLAMATION

- ***Abandoned Uranium Mines Location and Evaluation: Utah.*** *Field Technician.* Work performed for Bureau of Land Management. Mines were prioritized for reclamation based on health and safety criteria, including measured radiation levels. Collected data using Trimble GPS systems and compiled it into a GIS database after differential correction.

PROFESSIONAL INSTRUCTION

- ***Geology, Physical Science and Astronomy Courses: Utah Valley State College.*** *Adjunct Faculty.* Responsible for conducting oral, visual and written presentations of technical material to a wide variety of audiences.

- ***Geology Courses: Brigham Young University, Provo, Utah.*** *Teaching and Research Assistant.* Taught geology courses and assisted with summer field camp for seniors in geology, which included geologic and structural mapping, measuring geologic sections and environmental field methods. Led a field trip to Hidalgo, Mexico, to assess groundwater problems associated with wastewater from Mexico City and set up exchange of graduate students between La Universidad Autonoma De Hidalgo and Brigham Young University.

PROFESSIONAL EMPLOYMENT HISTORY

2006 – Present	President and Operator of Clement Drilling & Geophysical, Inc.
1997 – 2006	Project Manager and Geophysical Department Manager, Maxim Technologies (now Tetra Tech)
1996 – 1997	Adjunct Faculty, Utah Valley State College
1993 – 1997	Geologist, Mayo and Associates

VEGETATION OF THE WASTE ROCK EXPANSION SITE

FOR THE SKYLINE MINES

Prepared by

MT. NEBO SCIENTIFIC, INC.
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Patrick D. Collins, Ph.D.

for

CANYON FUEL COMPANY, LLC.
Skyline Mines
HC 35 Box 380
Helper, Utah 84526

June 2007

TABLE OF CONTENTS

INTRODUCTION

Canyon Fuel Company is planning to expand the Skyline Mine's waste rock site. The current waste rock site is located about one mile southeast of the town of Scofield, Utah. The proposed new expansion site is east and adjacent to the current waste rock area (see attached Vegetation Map). Elevation of the expansion site ranges from 7,870 to 8,170 ft above sea level. Slope exposure is primarily north, northwest and west with angles from 20 to 25 degrees. The plant communities that would be impacted by the new site are sagebrush/grass and aspen.

Because site planning and designs were finalized late in the 2006 growing season, it was too late to record credible quantitative vegetation data for permitting purposes at that time. Therefore, a preliminary report was written that included **qualitative** information about the proposed new waste rock site including the sample plan and designs that would be implemented in 2007 when the sample season was more appropriate for credible data. The 2006 report was called: *Preliminary Vegetation Report for the Proposed Waste Rock Expansion Site for the Skyline Mines.*

The purpose of this report is to provide additional information and followup **quantitative** data for the plant communities that would be impacted by expansion of the proposed new waste rock site. It also provides locations and data for reference areas chosen to represent future revegetation success standards following final reclamation.

METHODS

Methodologies used for this study were performed in accordance with the guidelines supplied by the State of Utah, Division of Oil, Gas and Mining (DOGM). Quantitative and qualitative data were taken in the plant communities that have been proposed for disturbance and reference areas chosen to represent them. These data sets were recorded May 30 - June 1, 2007.

The proposed waste rock expansion site was mapped and staked in the field by Canyon Fuel prior to the vegetation field work. The reference areas chosen were approximately one acre in size and was marked in the field using a GPS instrument. The sample area coordinates for the proposed disturbed and reference areas are given below.

GPS COORDINATES FOR
SKYLINE MINE
WASTE ROCK EXPANSION AREA

Waypoint Name	Zone	Easting	Northing	Notes
CFSPDS	12S	0487100	4396364	Proposed Disturbed Sagebrush/Grass
CFSSRF	12S	0487176	4396286	Sagebrush/Grass Reference Area
CFSPDA	12S	0487183	4396424	Proposed Disturbed Aspen
CFSARF	12S	0487305	4396384	Aspen Reference Area

Sampling Design and Transect/Quadrat Placement

Transect lines for vegetation sampling were placed randomly within the boundaries of the proposed disturbed and reference areas. The transect placement technique was employed with the goal to adequately sample a representative subset of the entire site as a whole. Once the transects were established, quadrat locations for sampling were chosen using random numbers from the transect lines with the objective to record data without preconceived bias.

Cover and Composition

Cover estimates were made using ocular methods with meter square quadrats. Species composition, cover by species, and relative frequencies were also assessed from the quadrats. Additional information recorded on the raw data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes. Plant nomenclature follows "A Utah Flora" (Welsh et al., 2003).

Woody Species Density

Density of woody plant species for the proposed disturbed and reference areas was estimated using the point-quarter method. In this method, random points were placed on the sample sites and measured into four quarters. The distances to the nearest woody plant species were then recorded in each quarter. The average point-to-individual distance was equal to the square root

of the mean area per individual. The number of individuals per acre was the end results of the calculations.

Sample Size & Adequacy

Sampling adequacy for cover and density was attempted by using the formula given below.

$$nMIN = \frac{t^2 s^2}{(dx)^2}$$

where,

nMIN	= minimum adequate sample
t	= appropriate confidence t-value
s	= standard deviation
x	= sample mean
d	= desired change from mean

Statistical Analyses

Student's t-tests were employed to compare the total living cover and total woody species density of each proposed disturbed borehole site with its reference area.

Photographs

Color photographs of the sample areas were taken at the time of sampling and have been submitted with this report.

Threatened & Endangered Plant Species

Prior to recording quantitative data on the plant communities, a sensitive plant species survey was conducted.

Raw Data

The raw data for cover and frequency have been summarized on spreadsheets and were included in the Appendix of this report.

RESULTS

Proposed Disturbed Sagebrush/Grass Community

A sagebrush/grass plant community would be impacted by construction of the waste rock expansion site for the Skyline Mines (see PHOTOGRAPHS). The quantitative sampling summary for species cover of this community is shown on Table 1. It indicates that the dominant

shrub species of the area were Vasey sagebrush (*Artemisia tridentata* var. *vaseyana*), low rabbitbrush (*Chrysothamnus viscidiflorus*) and snowberry (*Symphoricarpos oreophilus*). Individual forb species covers were not as high as the shrubs mentioned above, but collectively, the forbs were well-represented. Some of the more common forbs were balsamroot *(Balsamorhiza sagittata*), Watson's penstemon (*Penstemon watsonii*) and longleaf phlox (*Phlox longifolia*). Grasses were also important in the sagebrush/grass community; the most common grass species present were bluebunch wheatgrass (*Elymus spicatus*) and Sandberg's bluegrass (*Poa secunda*).

The total living cover for the proposed disturbed sagebrush/grass community was estimated at 67.17% (Table 2-A). The composition of the living cover by lifeform, was comprised of 45.80% shrubs, 27.68% grasses and 25.11% forbs (Table 2-B). The woody species density measurements indicated that there were 7,539 individuals per acre with the most important species being Vasey sagebrush, snowberry and low rabbitbrush (Table 3).

Sagebrush/Grass Reference Area

A reference area was sampled to be compared with the sagebrush/grass community that would be impacted by disturbance (see PHOTOGRAPHS). The same reference area could also be used for comparisons with the waste rock site's revegetated land following final reclamation. At that time, it would be used to establish revegetation success standards.

Table 4 shows the cover of the sagebrush/grass reference area by species. Like the area proposed for disturbance, Vasey sagebrush dominated the shrub cover, but by a greater margin. Most common forbs in the reference area were balsamroot, longleaf phlox and silky lupine *(Lupinus sericeus*). Once again, the most common grass species here were bluebunch wheatgrass and Sandberg's bluegrass.

The total living cover for the reference area was estimated at 64.83% (Table 5-A), of which was comprised of 40.21% shrubs, 32.28% forbs and 27.51% grasses (Table 5-B). The woody species density of the area was 6,124 individuals per acre and was dominating by Vasey sagebrush, but low rabbitbrush and snowberry were also important (Table 6).

Proposed Disturbed Aspen Community

Another plant community proposed for disturbance by waste rock expansion construction was an aspen forest (see PHOTOGRAPHS). Accordingly, aspen (*Populus tremuloides*) trees were common in the overstory cover (Table 7). The dominate woody understory species was snowberry. Several forb species were present in the sample quadrats, the most common were Lanszwert's sweetpea *(Lathyrus lanszwertii*), tall bluebell (*Mertensia arizonica*) and western coneflower *(Rudbeckia occidentalis*). Prevalent grass species in this community were mountain brome (*Bromus carinatus*), Sandberg's bluegrass and bluebunch wheatgrass.

The total cover values in the proposed disturbed aspen community have been listed in Table 8.

Overstory cover was estimated at 11.17%, whereas understory was 70.17% – combined they created a total living cover of 81.33% (Table 8-A). The composition of the understory cover was comprised of 42.32% grasses, 37.43% forbs and 20.25% trees and shrubs (Table 8-B). The total woody species density was 1,844 individuals per acre (Table 9), and was comprised of snowberry, aspen and Wood's rose (*Rosa woodsii*).

Aspen Reference Area

The aspen community chosen to be used for future revegetation success standards was located nearby, but outside that of which has been proposed for disturbance by the waste rock expansion (see PHOTOGRAPHS). This community had an overstory cover of 20.17%, and was comprised of aspen trees (Table 10). Understory woody species present in the sample quadrats were aspen and snowberry. The understory forb cover consisted of several species, the most common being Lanszwert's sweetpea and northern bedstraw (*Galium boreale*). Like the above community, the most common grasses were Sandberg's bluegrass, mountain brome and bluebunch wheatgrass.

The living plant cover consisted of 20.17% overstory species and 68.67% understory. With the two combined, the total living cover was 88.83% (Table 11-A). The composition of the understory was comprised of 56.60% forbs, 32.95% grasses and 10.45% shrubs (Table 11-B). Woody species density totaled 1,457 trees and shrubs per acre and was entirely aspen and snowberry – both nearly equally represented for this parameter.

Threatened & Endangered Plant Species Survey

No threatened, endangered, endemic or otherwise sensitive plant species were found in the sample areas.

Table 1: Cover, standard deviation and frequency by species of the Skyline Mine Waste Rock Site (2007).

Proposed Disturbed Sagebrush/Grass Community	Mean Percent	Standard Deviation	Percent Frequency
TREES & SHRUBS			
Amelanchier utahensis	1.33	5.47	10.00
Artemisia tridentata var. vaseyana	15.17	12.01	76.67
Chrysothamnus viscidiflorus	8.67	8.26	66.67
Purshia tridentata	0.50	2.69	3.33
Symphoricarpos oreophilus	5.83	8.07	43.33
FORBS			
Agoseris glauca	1.83	4.18	20.00
Antennaria parvifolia	0.33	1.25	6.67
Balsamorhiza sagittata	3.50	6.34	26.67
Cirsium sp.	0.33	1.25	6.67
Cynoglossum officinale	0.50	1.98	6.67
Delphinium nuttallianum	0.50	1.50	10.00
Erigeron engelmannii	0.33	1.80	3.33
Eriogonum umbellatum var. majus	0.50	1.98	6.67
Hedysarum boreale	1.50	3.20	20.00
Lupinus sericeus	0.83	2.27	13.33
Penstemon watsonii	2.83	4.41	33.33
Phlox longifolia	2.67	3.82	40.00
Senecio sp.	0.67	2.49	6.67
Taraxacum officinale	0.17	0.90	3.33
Wyethia amplexicaulis	0.67	3.59	3.33
GRASSES			
Elymus salinus	1.00	2.71	13.33
Elymus spicatus	9.83	9.96	60.00
Koeleria macrantha	2.67	7.16	16.67
Poa secunda	5.00	7.07	40.00

Table 2: Mean total cover, composition, standard deviation and sample size at the Skyline Mine Waste Rock Site (2007).

Proposed Disturbed Sagebrush/Grass Community	Mean	Standard Deviation	Sample Size
A. TOTAL COVER			
Understory	67.17	10.62	30
Litter	12.97	6.42	30
Bareground	10.80	9.71	30
Rock	9.07	7.89	30
B. % COMPOSITION			
Shrubs	45.80	21.70	30
Forbs	25.11	18.57	30
Grasses	27.68	17.21	30

Table 3: Woody Species Density of the Skyline Mine Waste Rock Site (2007).

Proposed Disturbed Sagebrush/Grass Community	
Species	**Individuals Per Acre**
Amelanchier utahensis	188.47
Artemisia tridentata	3957.91
Chrysothamnus viscidiflorus	1633.42
Chrysothamnus nauseosus	62.82
Purshia tridentata	62.82
Symphoricarpos oreophilus	1633.42
TOTAL	7538.87

Table 4: Cover, standard deviation and frequency by species of the Skyline Mine Waste Rock Site (2007).

Sagebrush/Grass Reference Area	Mean Percent	Standard Deviation	Percent Frequency
UNDERSTORY			
TREES & SHRUBS			
Amelanchier utahensis	0.83	2.61	10.00
Artemisia tridentata var. vaseyana	19.17	13.04	90.00
Chrysothamnus nauseosus	3.00	4.20	36.67
Purshia tridentata	3.00	7.14	23.33
Symphoricarpos oreophilus	0.50	1.98	6.67
FORBS			
Agoseris glauca	0.67	1.70	13.33
Antennaria parvifolia	0.33	1.25	6.67
Balsamorhiza sagittata	11.33	7.95	83.33
Cirsium sp.	0.33	1.25	6.67
Delphinium nuttallianum	0.50	1.50	10.00
Eriogonum umbellatum var. majus	0.17	0.90	3.33
Gayophytum ramosissimum	0.17	0.90	3.33
Hedysarum boreale	0.83	1.86	16.67
Lupinus sericeus	2.00	2.77	36.67
Penstemon watsonii	1.17	3.34	13.33
Phlox longifolia	3.00	3.79	43.33
Senecio sp.	0.17	0.90	3.33
GRASSES			
Elymus salinus	1.50	3.45	16.67
Elymus spicatus	8.83	7.38	66.67
Koeleria macrantha	1.00	5.39	3.33
Poa secunda	6.33	9.99	46.67

Table 5: Mean total cover, composition, standard deviation and sample size at the Skyline Mine Waste Rock Site (2007).

Sagebrush/Grass Reference Area	Mean	Standard Deviation	Sample Size
A. TOTAL COVER			
Understory	64.83	7.24	30
Litter	10.33	5.76	30
Bareground	13.00	7.26	30
Rock	11.83	5.55	30
B. % COMPOSITION			
Shrubs	40.21	19.42	30
Forbs	32.28	16.49	30
Grasses	27.51	16.08	30

Table 6: Woody Species Density of the Skyline Mine Waste Rock Site (2007).

Sagebrush/Grass Reference Area	
Species	**Individuals Per Acre**
Artemisia tridentata	4440.07
Purshia tridentata	204.14
Symphoricarpos oreophilus	459.32
Amelanchier utahensis	255.18
Chrysothamnus viscidiflorus	765.53
TOTAL	6124.23

Table 7: Cover, standard deviation and frequency by species of the Skyline Mine Waste Rock Site (2007).

Proposed Disturbed Aspen Community	Mean Percent	Standard Deviation	Percent Frequency
OVERSTORY			
Populus tremuloides	11.17	17.59	43.33
UNDERSTORY			
TREES & SHRUBS			
Populus tremuloides	0.67	2.49	6.67
Rosa woodsii	0.17	0.90	3.33
Symphoricarpos oreophilus	14.17	17.23	63.33
FORBS			
Achillea millefolium	1.83	3.53	23.33
Cirsium sp.	0.50	1.50	10.00
Cynoglossum officinale	0.33	1.25	6.67
Delphinium barbeyi	2.00	5.26	13.33
Delphinium nuttallianum	0.67	2.13	10.00
Galium boreale	2.00	4.58	20.00
Gayophytum ramosissimum	0.33	1.80	3.33
Lathyrus lanszwertii	8.00	6.53	70.00
Lupinus sericeus	0.67	2.13	10.00
Mertensia arizonica	3.83	5.58	36.67
Polemonium foliosissimum	0.33	1.80	3.33
Rudbeckia occidentalis	3.33	6.50	26.67
Senecio sp.	0.50	1.98	6.67
Taraxacum officinale	0.50	1.50	10.00
Thalictrum fendleri	0.33	1.25	6.67
Urtica dioica	0.17	0.90	3.33
GRASSES			
Bromus carinatus	13.83	14.70	76.67
Elymus spicatus	4.83	6.12	46.67
Festuca thurberi	0.83	2.61	10.00
Poa fendleriana	0.67	2.13	10.00
Poa secunda	9.67	12.58	50.00

Table 8: Mean total cover, composition, standard deviation and sample size at the Skyline Mine Waste Rock Site (2007).

Proposed Disturbed Aspen Community	Mean	Standard Deviation	Sample Size
A. TOTAL COVER			
Overstory (O)	11.17	17.59	
Understory (U)	70.17	7.90	30
Litter	14.33	8.15	30
Bareground	13.13	10.19	30
Rock	2.37	5.23	30
O + U	81.33	17.32	30
B. % COMPOSITION			
Trees & Shrubs	20.25	22.98	30
Forbs	37.43	19.55	30
Grasses	42.32	21.30	30

Table 9: Woody Species Density of the Skyline Mine Waste Rock Site (2007).

Proposed Disturbed Aspen Community	
Species	**Individuals Per Acre**
Populus tremuloides	445.64
Rosa woodsii	15.37
Symphoricarpos oreophilus	1383.01
TOTAL	1844.02

Table 10: Cover, standard deviation and frequency by species of the Skyline Mine Waste Rock Site (2007).

Aspen Reference Area			
OVERSTORY			
Populus tremuloides	20.17	20.59	63.33
UNDERSTORY			
TREES & SHRUBS			
Populus tremuloides	3.67	7.06	26.67
Symphoricarpos oreophilus	3.33	6.62	23.33
FORBS			
Achillea millefolium	3.33	5.22	33.33
Cynoglossum officinale	0.50	1.98	6.67
Erysimum asperum	0.17	0.90	3.33
Galium boreale	9.17	8.37	66.67
Hackelia patens	1.33	3.64	13.33
Hydrophyllum capitatum	1.50	3.20	20.00
Lathyrus lanszwertii	10.50	6.24	86.67
Mertensia arizonica	0.33	1.80	3.33
Osmorhiza depauperata	0.50	1.98	6.67
Ranunculus sp.	0.83	2.27	13.33
Rudbeckia occidentalis	3.00	4.58	33.33
Senecio sp.	1.00	3.00	10.00
Taraxacum officinale	0.67	1.70	13.33
Thalictrum fendleri	2.00	4.00	20.00
Urtica dioica	4.00	6.38	33.33
GRASSES			
Bromus carinatus	7.50	7.93	56.67
Elymus spicatus	4.50	5.22	46.67
Festuca thurberi	1.83	3.76	20.00
Poa secunda	9.00	6.63	83.33

Table 11: Mean total cover, composition, standard deviation and sample size at the Skyline Mine Waste Rock Site (2007).

Aspen Reference Area		
A. TOTAL COVER		
Overstory (O)	20.17	20.59
Understory (U)	68.67	9.48
Litter	25.33	9.03
Bareground	4.63	2.69
Rock	1.37	0.91
O + U	88.83	22.16
B. % COMPOSITION		
Shrubs	10.45	13.12
Forbs	56.60	15.63
Grasses	32.95	14.15

Table 12: Woody Species Density of the Skyline Mine Waste Rock Site (2007).

Aspen Reference Area	
Species	**Individuals Per Acre**
Populus tremuloides	716.47
Symphoricarpos oreophilus	740.75
TOTAL	1457.22

SUMMARY & CONCLUSIONS

Data of plant communities that have been proposed for disturbances caused by construction for expansion of the waste rock site were compared statistically with their reference areas, or similar communities chosen to represent future revegetation success standards. Figure 1 shows the results of Student's t-test analyses of total living covers. When the **total living cover** of the proposed disturbed sagebrush/grass community was compared to its reference area, the difference was non-significant statistically (Figure 1). Similarly, when the total living cover of the proposed disturbed aspen community was compared to its reference area, the difference here was also non-significant.

Woody species densities of those communities proposed for disturbance were also compared with their respective reference areas (Figure 2). Results of statistical comparisons suggest that there was no significant difference between the proposed disturbed sagebrush/grass community and its reference area. The same non-significant findings were suggested by statistical comparisons of woody species density between the proposed disturbed aspen community and its reference area.

In conclusion, results from quantitatively sampling those plant communities proposed for disturbance and their respective reference areas have been submitted in this report. Specific parameters of these communities have been compared statistically with results suggesting that the

reference areas chosen for revegetation success standards at the time of final reclamation may be appropriate.

FIGURE 1. A statistical comparison (Student's t-tests) of the **total living cover** between the proposed disturbed and reference areas.

	$\bar{x}$	s	n	t	df	SL
Sagebrush/Grass						
Proposed Disturbed:	67.17	10.62	30			
Reference Area:	64.83	7.24	30			
t-test				0.997	58	N.S.
Aspen						
Proposed Disturbed:	81.33	17.32	30			
Reference Area:	88.83	22.16	30			
t-test				1.461	58	N.S.

$\bar{x}$ = mean
s = standard deviation
n = sample size
t = Student's t-value
df = degrees of freedom
SL= Significance Level
N.S.=Non-Significant

FIGURE 2. A statistical comparison (Student's t-tests) of the **woody species density** between the proposed disturbed reference areas.

	$\bar{x}$	s	n	t	df	SL
Sagebrush/Grass						
Proposed Disturbed:	7538.87	3486.44	30			
Reference Area:	6124.23	2358.70	30			
t-test				1.841	58	N.S.
Aspen						
Proposed Disturbed:	1844.02	1135.23	30			
Reference Area:	1457.22	1422.19	30			
t-test				1.164	58	N.S.

$\bar{x}$ = mean
s = standard deviation
n = sample size
t = Student's t-value
df = degrees of freedom
SL= *Significance Level*
N.S.=Non-Significant

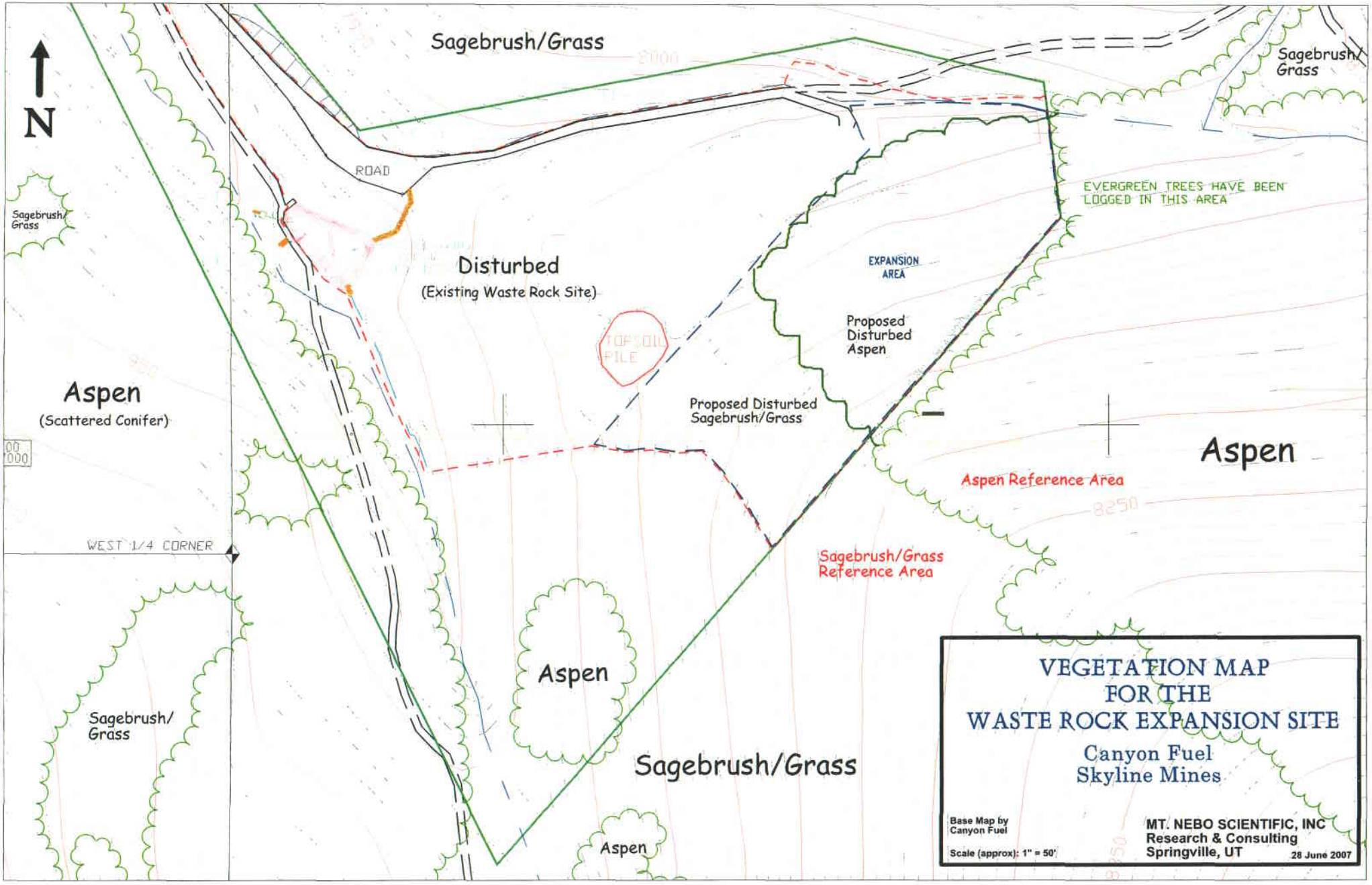
COLOR PHOTOGRAPHS OF THE SAMPLE AREAS

Photo 1: Proposed Disturbed Sagebrush/Grass

Photo 2: Sagebrush/Grass Reference Area

Photo 3: Proposed Disturbed Aspen

Photo 4: Aspen Reference Area


N
Sagebrush/Grass
Sagebrush/
Grass
ROAD
EVERGREEN TREES HAVE BEEN
LOGGED IN THIS AREA
Sagebrush/
Grass
Disturbed
(Existing Waste Rock Site)
EXPANSION
AREA
TOPSOIL
PILE
Proposed
Disturbed
Aspen
Aspen
(Scattered Conifer)
Proposed Disturbed
Sagebrush/Grass
Aspen
Aspen Reference Area
8250
WEST 1/4 CORNER
Sagebrush/Grass
Reference Area
Aspen
Sagebrush/
Grass
Sagebrush/Grass
Aspen
VEGETATION MAP
FOR THE
WASTE ROCK EXPANSION SITE
Canyon Fuel
Skyline Mines
Base Map by
Canyon Fuel
Scale (approx): 1" = 50'
MT. NEBO SCIENTIFIC, INC
Research & Consulting
Springville, UT
28 June 2007

APPENDIX

(Raw Data)

CANYON FUEL
Skyline Mine
Proposed Disturbed Sagebrush/Grass
Proposed Waste Rock Site
Exposure: 25 deg
Slope: WSW

Sample Date: 30 May 2007	1.00	2.00	3.00	4.00	5.00	6.00	7.00
UNDERSTORY							
TREES & SHRUBS							
Amelanchier utahensis	0.00	5.00	5.00	0.00	0.00	0.00	0.00
Artemisia tridentata var. vaseyana	20.00	20.00	30.00	5.00	15.00	0.00	30.00
Chrysothamnus viscidiflorus	15.00	10.00	20.00	0.00	15.00	5.00	20.00
Purshia tridentata	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Symphoricarpos oreophilus	0.00	0.00	0.00	10.00	0.00	0.00	0.00
FORBS							
Agoseris glauca	5.00	0.00	0.00	5.00	10.00	15.00	0.00
Antennaria parvifolia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balsamorhiza sagittata	0.00	10.00	0.00	10.00	0.00	0.00	0.00
Cirsium sp.	0.00	0.00	0.00	5.00	0.00	0.00	0.00
Cynoglossum officinale	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delphinium nuttallianum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erigeron engelmannii	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eriogonum umbellatum var. majus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hedysarum boreale	10.00	0.00	0.00	0.00	0.00	0.00	0.00
Lupinus sericeus	0.00	10.00	0.00	5.00	0.00	0.00	0.00
Penstemon watsonii	5.00	0.00	10.00	0.00	0.00	0.00	0.00
Phlox longifolia	0.00	0.00	0.00	5.00	5.00	15.00	10.00
Senecio sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taraxacum officinale	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wyethia amplexicaulis	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GRASSES							
Elymus salinus	0.00	0.00	0.00	0.00	0.00	0.00	5.00
Elymus spicatus	10.00	0.00	0.00	10.00	20.00	0.00	0.00
Koeleria macrantha	0.00	0.00	0.00	0.00	0.00	25.00	0.00
Poa secunda	0.00	5.00	10.00	10.00	15.00	20.00	0.00
COVER							
Understory	65.00	60.00	75.00	65.00	80.00	80.00	65.00
Litter	15.00	25.00	15.00	10.00	5.00	5.00	15.00
Bareground	10.00	10.00	5.00	15.00	5.00	5.00	10.00
Rock	10.00	5.00	5.00	10.00	10.00	10.00	10.00
% COMPOSITION							
Shrubs	53.85	58.33	73.33	23.08	37.50	6.25	76.92
Forbs	30.77	33.33	13.33	46.15	18.75	37.50	15.38
Grasses	15.38	8.33	13.33	30.77	43.75	56.25	7.69

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.00	0.00	5.00	35.00	0.00	15.00	0.00	15.00	30.00	30.00
5.00	10.00	0.00	0.00	15.00	5.00	5.00	10.00	0.00	0.00
0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	15.00	15.00	10.00	25.00	0.00	25.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	20.00	5.00	0.00	15.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	5.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	5.00	5.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
5.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	10.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00
20.00	0.00	15.00	10.00	30.00	5.00	20.00	0.00	0.00	10.00
0.00	30.00	5.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	10.00	5.00
75.00	65.00	65.00	85.00	80.00	55.00	70.00	50.00	85.00	70.00
10.00	10.00	10.00	10.00	10.00	15.00	25.00	10.00	10.00	20.00
10.00	15.00	20.00	4.00	9.00	25.00	4.00	30.00	4.00	5.00
5.00	10.00	5.00	1.00	1.00	5.00	1.00	10.00	1.00	5.00
60.00	30.77	7.69	76.47	37.50	54.55	42.86	50.00	64.71	42.86
13.33	23.08	61.54	11.76	12.50	27.27	0.00	30.00	23.53	35.71
26.67	46.15	30.77	11.76	50.00	9.09	57.14	20.00	11.76	21.43

18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	10.00	30.00	0.00	0.00	10.00	15.00	20.00	25.00	0.00
10.00	25.00	10.00	10.00	0.00	25.00	25.00	15.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	0.00	0.00	20.00	0.00	10.00	0.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	15.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	10.00	0.00	10.00
5.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.00	0.00	10.00	0.00	10.00	0.00	15.00	0.00
0.00	0.00	5.00	5.00	10.00	5.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
0.00	10.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
15.00	0.00	10.00	30.00	0.00	10.00	0.00	20.00	20.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
0.00	0.00	15.00	0.00	0.00	0.00	5.00	0.00	0.00	15.00
70.00	60.00	70.00	65.00	50.00	60.00	70.00	70.00	65.00	60.00
10.00	15.00	10.00	25.00	10.00	10.00	5.00	5.00	10.00	20.00
5.00	15.00	5.00	5.00	5.00	5.00	10.00	5.00	5.00	15.00
15.00	10.00	15.00	5.00	35.00	25.00	15.00	20.00	20.00	5.00
57.14	58.33	57.14	46.15	0.00	75.00	57.14	57.14	46.15	0.00
21.43	25.00	7.14	7.69	90.00	8.33	35.71	14.29	23.08	25.00
21.43	16.67	35.71	46.15	10.00	16.67	7.14	28.57	30.77	41.67

CANYON FUEL
Skyline Mine
Sagebrush/Grass
Proposed Waste Rock Site
Exposure: 25 deg
Slope: WSW
Sample Date: 30 May 2007

28.00	29.00	30.00	Mean	SDev	Freq	
						UNDERSTORY
						TREES & SHRUBS
30.00	0.00	0.00	1.33	5.47	10.00	*Amelanchier utahensis*
20.00	5.00	20.00	15.17	12.01	76.67	*Artemisia tridentata var. vaseyan*
0.00	0.00	0.00	8.67	8.26	66.67	*Chrysothamnus viscidiflorus*
0.00	0.00	0.00	0.50	2.69	3.33	*Purshia tridentata*
5.00	5.00	0.00	5.83	8.07	43.33	*Symphoricarpos oreophilus*
						FORBS
0.00	0.00	0.00	1.83	4.18	20.00	*Agoseris glauca*
0.00	0.00	0.00	0.33	1.25	6.67	*Antennaria parvifolia*
0.00	0.00	20.00	3.50	6.34	26.67	*Balsamorhiza sagittata*
0.00	0.00	0.00	0.33	1.25	6.67	*Cirsium sp.*
10.00	0.00	0.00	0.50	1.98	6.67	*Cynoglossum officinale*
0.00	0.00	0.00	0.50	1.50	10.00	*Delphinium nuttallianum*
0.00	0.00	10.00	0.33	1.80	3.33	*Erigeron engelmannii*
0.00	0.00	0.00	0.50	1.98	6.67	*Eriogonum umbellatum var. maju*
0.00	0.00	0.00	1.50	3.20	20.00	*Hedysarum boreale*
0.00	0.00	0.00	0.83	2.27	13.33	*Lupinus sericeus*
0.00	0.00	0.00	2.83	4.41	33.33	*Penstemon watsonii*
0.00	0.00	0.00	2.67	3.82	40.00	*Phlox longifolia*
0.00	0.00	0.00	0.67	2.49	6.67	*Senecio sp.*
0.00	0.00	0.00	0.17	0.90	3.33	*Taraxacum officinale*
0.00	0.00	0.00	0.67	3.59	3.33	*Wyethia amplexicaulis*
						GRASSES
0.00	0.00	0.00	1.00	2.71	13.33	*Elymus salinus*
0.00	30.00	10.00	9.83	9.96	60.00	*Elymus spicatus*
0.00	0.00	0.00	2.67	7.16	16.67	*Koeleria macrantha*
20.00	0.00	0.00	5.00	7.07	40.00	*Poa secunda*
						COVER
85.00	40.00	60.00	67.17	10.62		Understory
10.00	9.00	30.00	12.97	6.42		Litter
4.00	50.00	9.00	10.80	9.71		Bareground
1.00	1.00	1.00	9.07	7.89		Rock
						% COMPOSITION
64.71	25.00	33.33	45.80	21.70		Shrubs
11.76	0.00	50.00	25.11	18.57		Forbs
23.53	75.00	16.67	27.68	17.21		Grasses

CANYON FUEL
Skyline Mine
Sagebrush/Grass Reference Area
Proposed Waste Rock
Exposure: 25 deg
Slope: WSW

Sample Date: 30 May 2007	1.00	2.00	3.00	4.00	5.00	6.00	7.00
UNDERSTORY							
TREES & SHRUBS							
Amelanchier utahensis	0.00	0.00	0.00	0.00	0.00	0.00	5.00
Artemisia tridentata var. vaseyana	5.00	15.00	15.00	0.00	30.00	15.00	35.00
Chrysothamnus nauseosus	10.00	0.00	0.00	0.00	0.00	5.00	0.00
Purshia tridentata	0.00	0.00	15.00	0.00	0.00	0.00	0.00
Symphoricarpos oreophilus	0.00	0.00	0.00	0.00	0.00	0.00	5.00
FORBS							
Agoseris glauca	0.00	5.00	0.00	0.00	0.00	5.00	0.00
Antennaria parvifolia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Balsamorhiza sagittata	35.00	15.00	20.00	20.00	10.00	5.00	10.00
Cirsium sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delphinium nuttallianum	5.00	0.00	0.00	0.00	0.00	0.00	0.00
Eriogonum umbellatum var. majus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gayophytum ramosissimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hedysarum boreale	0.00	5.00	0.00	0.00	0.00	0.00	5.00
Lupinus sericeus	0.00	5.00	0.00	0.00	5.00	0.00	5.00
Penstemon watsonii	0.00	0.00	0.00	0.00	0.00	15.00	0.00
Phlox longifolia	0.00	0.00	0.00	0.00	10.00	10.00	5.00
Senecio sp.	0.00	0.00	0.00	0.00	0.00	0.00	5.00
GRASSES							
Elymus salinus	0.00	10.00	0.00	0.00	0.00	10.00	0.00
Elymus spicatus	10.00	10.00	15.00	0.00	0.00	0.00	10.00
Koeleria macrantha	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa secunda	0.00	0.00	0.00	50.00	10.00	0.00	0.00
COVER							
Understory	65.00	65.00	65.00	70.00	65.00	65.00	85.00
Litter	5.00	15.00	5.00	5.00	10.00	5.00	5.00
Bareground	15.00	10.00	5.00	10.00	10.00	25.00	5.00
Rock	15.00	10.00	25.00	15.00	15.00	5.00	5.00
% COMPOSITION							
Shrubs	23.08	23.08	46.15	0.00	46.15	30.77	52.94
Forbs	61.54	46.15	30.77	28.57	38.46	53.85	35.29
Grasses	15.38	30.77	23.08	71.43	15.38	15.38	11.76

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.00	5.00	10.00	35.00	20.00	40.00	10.00	35.00	40.00	15.00
5.00	0.00	10.00	0.00	5.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	0.00	10.00	0.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	20.00	5.00	15.00	15.00	0.00	5.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	5.00	0.00	5.00	5.00	0.00	5.00
5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	5.00	0.00	5.00	0.00	5.00	0.00	5.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	10.00	0.00
20.00	10.00	15.00	15.00	0.00	10.00	0.00	15.00	0.00	25.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	10.00	10.00	0.00	0.00	0.00	15.00	0.00	10.00	0.00
70.00	50.00	70.00	65.00	65.00	75.00	60.00	65.00	65.00	65.00
20.00	15.00	15.00	15.00	10.00	15.00	5.00	10.00	10.00	25.00
5.00	20.00	5.00	5.00	10.00	5.00	25.00	20.00	10.00	5.00
5.00	15.00	10.00	15.00	15.00	5.00	10.00	5.00	15.00	5.00
57.14	10.00	28.57	61.54	38.46	66.67	50.00	61.54	61.54	23.08
7.14	50.00	35.71	15.38	53.85	20.00	25.00	15.38	7.69	38.46
35.71	40.00	35.71	23.08	7.69	13.33	25.00	23.08	30.77	38.46

18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	30.00	15.00	5.00	0.00	15.00	45.00	15.00	30.00	10.00
5.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	10.00	10.00
0.00	0.00	0.00	35.00	0.00	0.00	0.00	10.00	10.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	15.00	25.00	10.00	20.00	10.00	15.00	10.00	10.00	0.00
0.00	5.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	5.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
10.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	0.00	5.00	20.00	0.00	10.00	10.00	10.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	15.00	0.00	20.00	10.00	0.00	10.00	5.00	0.00
55.00	65.00	60.00	70.00	60.00	55.00	70.00	55.00	65.00	50.00
5.00	10.00	5.00	5.00	10.00	5.00	10.00	25.00	5.00	10.00
25.00	15.00	20.00	5.00	20.00	15.00	10.00	5.00	25.00	25.00
15.00	10.00	15.00	20.00	10.00	25.00	10.00	15.00	5.00	15.00
27.27	46.15	25.00	57.14	0.00	45.45	64.29	45.45	76.92	40.00
45.45	53.85	41.67	14.29	66.67	18.18	21.43	18.18	15.38	40.00
27.27	0.00	33.33	28.57	33.33	36.36	14.29	36.36	7.69	20.00

CANYON FUEL
Skyline Mine
Sagebrush/Grass Reference Area
Proposed Waste Rock
Exposure: 25 deg
Slope: WSW
Sample Date: 30 May 2007

28.00	29.00	30.00	Mean	SDev	Freq	
						UNDERSTORY
						TREES & SHRUBS
0.00	10.00	10.00	0.83	2.61	10.00	*Amelanchier utahensis*
15.00	25.00	0.00	19.17	13.04	90.00	*Artemisia tridentata var. vaseyan*
10.00	0.00	0.00	3.00	4.20	36.67	*Chrysothamnus nauseosus*
0.00	0.00	0.00	3.00	7.14	23.33	*Purshia tridentata*
0.00	0.00	0.00	0.50	1.98	6.67	*Symphoricarpos oreophilus*
						FORBS
0.00	0.00	5.00	0.67	1.70	13.33	*Agoseris glauca*
0.00	0.00	0.00	0.33	1.25	6.67	*Antennaria parvifolia*
10.00	10.00	0.00	11.33	7.95	83.33	*Balsamorhiza sagittata*
0.00	0.00	0.00	0.33	1.25	6.67	*Cirsium sp.*
0.00	0.00	0.00	0.50	1.50	10.00	*Delphinium nuttallianum*
0.00	0.00	0.00	0.17	0.90	3.33	*Eriogonum umbellatum var. maju*
0.00	0.00	0.00	0.17	0.90	3.33	*Gayophytum ramosissimum*
0.00	0.00	0.00	0.83	1.86	16.67	*Hedysarum boreale*
10.00	0.00	0.00	2.00	2.77	36.67	*Lupinus sericeus*
0.00	0.00	0.00	1.17	3.34	13.33	*Penstemon watsonii*
5.00	10.00	0.00	3.00	3.79	43.33	*Phlox longifolia*
0.00	0.00	0.00	0.17	0.90	3.33	*Senecio sp.*
						GRASSES
0.00	10.00	0.00	1.50	3.45	16.67	*Elymus salinus*
20.00	0.00	10.00	8.83	7.38	66.67	*Elymus spicatus*
0.00	0.00	30.00	1.00	5.39	3.33	*Koeleria macrantha*
0.00	10.00	10.00	6.33	9.99	46.67	*Poa secunda*
						COVER
70.00	75.00	65.00	64.83	7.24		Understory
10.00	5.00	15.00	10.33	5.76		Litter
10.00	15.00	10.00	13.00	7.26		Bareground
10.00	5.00	10.00	11.83	5.55		Rock
						% COMPOSITION
35.71	46.67	15.38	40.21	19.42		Shrubs
35.71	26.67	7.69	32.28	16.49		Forbs
28.57	26.67	76.92	27.51	16.08		Grasses

CANYON FUEL
Skyline Mine
Waste Rock Site
Proposed Disturbed Aspen
Exposure: 25 deg
Slope: NW

Sample Date: 1 June 2007	1.00	2.00	3.00	4.00	5.00	6.00	7.00
OVERSTORY							
Populus tremuloides	0.00	0.00	10.00	20.00	0.00	0.00	0.00
UNDERSTORY							
TREES & SHRUBS							
Populus tremuloides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rosa woodsii	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Symphoricarpos oreophilus	5.00	0.00	15.00	15.00	15.00	55.00	35.00
FORBS							
Achillea millefolium	10.00	0.00	0.00	0.00	0.00	0.00	0.00
Cirsium sp.	0.00	0.00	0.00	5.00	0.00	0.00	0.00
Cynoglossum officinale	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delphinium barbeyi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Delphinium nuttallianum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Galium boreale	0.00	10.00	0.00	10.00	0.00	0.00	0.00
Gayophytum ramosissimum	10.00	0.00	0.00	0.00	0.00	0.00	0.00
Lathyrus lanszwertii	0.00	10.00	10.00	10.00	10.00	10.00	25.00
Lupinus sericeus	5.00	0.00	0.00	0.00	10.00	0.00	0.00
Mertensia arizonica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polemonium foliosissimum	0.00	0.00	10.00	0.00	0.00	0.00	0.00
Rudbeckia occidentalis	0.00	10.00	10.00	15.00	0.00	0.00	0.00
Senecio sp.	0.00	0.00	0.00	0.00	5.00	0.00	0.00
Taraxacum officinale	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thalictrum fendleri	5.00	0.00	0.00	0.00	0.00	0.00	0.00
Urtica dioica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GRASSES							
Bromus carinatus	35.00	25.00	0.00	0.00	20.00	0.00	10.00
Elymus spicatus	0.00	0.00	25.00	5.00	0.00	5.00	10.00
Festuca thurberi	0.00	0.00	0.00	0.00	0.00	5.00	0.00
Poa fendleriana	0.00	10.00	0.00	5.00	0.00	5.00	0.00
Poa secunda	0.00	0.00	0.00	0.00	10.00	0.00	10.00
COVER							
Overstory	0.00	0.00	10.00	20.00	0.00	0.00	0.00
Understory	70.00	65.00	70.00	65.00	70.00	80.00	90.00
Litter	14.00	1.00	19.00	14.00	13.00	10.00	5.00
Bareground	15.00	4.00	10.00	20.00	15.00	9.00	4.00
Rock	1.00	30.00	1.00	1.00	2.00	1.00	1.00
% COMPOSITION							
Shrubs	7.14	0.00	21.43	23.08	21.43	68.75	38.89
Forbs	42.86	46.15	42.86	61.54	35.71	12.50	27.78
Grasses	50.00	53.85	35.71	15.38	42.86	18.75	33.33
Overstory + Understory	70.00	65.00	80.00	85.00	70.00	80.00	90.00

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
75.00	0.00	25.00	0.00	0.00	25.00	10.00	0.00	30.00	15.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	10.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	10.00	0.00	45.00	40.00
5.00	0.00	0.00	10.00	10.00	5.00	10.00	0.00	0.00	0.00
5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	15.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	10.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	0.00	10.00	10.00	10.00	25.00	0.00	0.00	0.00	10.00
0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
15.00	10.00	10.00	0.00	10.00	0.00	5.00	0.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	0.00	10.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	65.00	0.00	10.00	15.00	5.00	10.00	10.00	0.00	5.00
0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	10.00	0.00
0.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	25.00	0.00	20.00	0.00	0.00	10.00	10.00	0.00
75.00	0.00	25.00	0.00	0.00	25.00	10.00	0.00	30.00	15.00
60.00	85.00	65.00	65.00	70.00	60.00	60.00	55.00	75.00	70.00
18.00	9.00	4.00	25.00	4.00	8.00	9.00	10.00	20.00	25.00
20.00	5.00	30.00	9.00	25.00	30.00	30.00	30.00	4.00	4.00
2.00	1.00	1.00	1.00	1.00	2.00	1.00	5.00	1.00	1.00
0.00	0.00	0.00	30.77	0.00	0.00	16.67	0.00	73.33	57.14
75.00	11.76	61.54	53.85	50.00	58.33	66.67	63.64	0.00	35.71
25.00	88.24	38.46	15.38	50.00	41.67	16.67	36.36	26.67	7.14
135.00	85.00	90.00	65.00	70.00	85.00	70.00	55.00	105.00	85.00

18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
5.00	10.00	10.00	0.00	0.00	50.00	0.00	10.00	40.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	0.00	0.00	0.00	20.00	5.00	10.00	50.00	50.00
0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
15.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	0.00	0.00	20.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	5.00	0.00	5.00	25.00	15.00	20.00	50.00	10.00	10.00
5.00	0.00	0.00	10.00	10.00	10.00	0.00	0.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	35.00	50.00	20.00	25.00	5.00	0.00	0.00	0.00	0.00
5.00	10.00	10.00	0.00	0.00	50.00	0.00	10.00	40.00	0.00
80.00	65.00	70.00	70.00	70.00	65.00	70.00	70.00	80.00	85.00
15.00	4.00	25.00	9.00	25.00	9.00	25.00	5.00	15.00	10.00
4.00	30.00	4.00	20.00	4.00	25.00	4.00	20.00	4.00	4.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00	1.00	1.00
0.00	15.38	0.00	0.00	0.00	30.77	7.14	14.29	62.50	58.82
43.75	23.08	28.57	50.00	14.29	23.08	64.29	14.29	25.00	17.65
56.25	61.54	71.43	50.00	85.71	46.15	28.57	71.43	12.50	23.53
85.00	75.00	80.00	70.00	70.00	115.00	70.00	80.00	120.00	85.00

CANYON FUEL
Skyline Mine
Waste Rock
Proposed Disturbed Aspen
Exposure: 25 deg
Slope: NW
Sample Date: 1 June 2007

28.00	29.00	30.00	Mean	SDev	Freq	
						OVERSTORY
0.00	0.00	0.00	11.17	17.59	43.33	*Populus tremuloides*
						UNDERSTORY
						TREES & SHRUBS
0.00	0.00	0.00	0.67	2.49	6.67	*Populus tremuloides*
5.00	0.00	0.00	0.17	0.90	3.33	*Rosa woodsii*
20.00	5.00	10.00	14.17	17.23	63.33	*Symphoricarpos oreophilus*
						FORBS
0.00	0.00	0.00	1.83	3.53	23.33	*Achillea millefolium*
0.00	0.00	0.00	0.50	1.50	10.00	*Cirsium sp.*
0.00	0.00	0.00	0.33	1.25	6.67	*Cynoglossum officinale*
0.00	0.00	0.00	2.00	5.26	13.33	*Delphinium barbeyi*
10.00	0.00	0.00	0.67	2.13	10.00	*Delphinium nuttallianum*
0.00	0.00	0.00	2.00	4.58	20.00	*Galium boreale*
0.00	0.00	0.00	0.33	1.80	3.33	*Gayophytum ramosissimum*
0.00	10.00	5.00	8.00	6.53	70.00	*Lathyrus lanszwertii*
0.00	0.00	0.00	0.67	2.13	10.00	*Lupinus sericeus*
0.00	10.00	10.00	3.83	5.58	36.67	*Mertensia arizonica*
0.00	0.00	0.00	0.33	1.80	3.33	*Polemonium foliosissimum*
0.00	0.00	0.00	3.33	6.50	26.67	*Rudbeckia occidentalis*
0.00	0.00	0.00	0.50	1.98	6.67	*Senecio sp.*
5.00	0.00	0.00	0.50	1.50	10.00	*Taraxacum officinale*
0.00	0.00	0.00	0.33	1.25	6.67	*Thalictrum fendleri*
0.00	0.00	0.00	0.17	0.90	3.33	*Urtica dioica*
						GRASSES
0.00	20.00	15.00	13.83	14.70	76.67	Bromus carinatus
15.00	10.00	10.00	4.83	6.12	46.67	*Elymus spicatus*
0.00	0.00	0.00	0.83	2.61	10.00	Festuca thurberi
0.00	0.00	0.00	0.67	2.13	10.00	*Poa fendleriana*
10.00	15.00	20.00	9.67	12.58	50.00	Poa secunda
						COVER
0.00	0.00	0.00	11.17	17.59		Overstory
65.00	70.00	70.00	70.17	7.90		Understory
30.00	25.00	25.00	14.33	8.15		Litter
4.00	4.00	3.00	13.13	10.19		Bareground
1.00	1.00	2.00	2.37	5.23		Rock
						% COMPOSITION
38.46	7.14	14.29	20.25	22.98		Shrubs
23.08	28.57	21.43	37.43	19.55		Forbs
38.46	64.29	64.29	42.32	21.30		Grasses
65.00	70.00	70.00	81.33	17.32		Overstory + Understory

CANYON FUEL
Skyline Mine
Waste Rock Site
Aspen Reference Area
Exposure: 23 deg
Slope: NNW

Sample Date: 1 June 2007	1.00	2.00	3.00	4.00	5.00	6.00	7.00
OVERSTORY							
Populus tremuloides	25.00	0.00	0.00	15.00	10.00	25.00	60.00
UNDERSTORY							
TREES & SHRUBS							
Populus tremuloides	10.00	0.00	0.00	0.00	0.00	0.00	0.00
Symphoricarpos oreophilus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FORBS							
Achillea millefolium	5.00	0.00	0.00	0.00	0.00	0.00	0.00
Cynoglossum officinale	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erysimum asperum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Galium boreale	10.00	15.00	15.00	20.00	15.00	10.00	15.00
Hackelia patens	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrophyllum capitatum	0.00	0.00	0.00	5.00	0.00	0.00	0.00
Lathyrus lanszwertii	20.00	10.00	10.00	15.00	15.00	10.00	15.00
Mertensia arizonica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Osmorhiza depauperata	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ranunculus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rudbeckia occidentalis	0.00	10.00	0.00	5.00	10.00	10.00	0.00
Senecio sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taraxacum officinale	0.00	0.00	0.00	5.00	0.00	0.00	0.00
Thalictrum fendleri	0.00	0.00	0.00	0.00	0.00	0.00	10.00
Urtica dioica	15.00	0.00	0.00	0.00	10.00	15.00	0.00
GRASSES							
Bromus carinatus	0.00	15.00	15.00	0.00	0.00	15.00	0.00
Elymus spicatus	10.00	0.00	10.00	5.00	10.00	10.00	10.00
Festuca thurberi	0.00	0.00	0.00	10.00	0.00	0.00	5.00
Poa secunda	0.00	15.00	20.00	5.00	10.00	10.00	10.00
COVER							
Overstory	25.00	0.00	0.00	15.00	10.00	25.00	60.00
Understory	70.00	65.00	70.00	70.00	70.00	80.00	65.00
Litter	25.00	30.00	25.00	20.00	25.00	15.00	30.00
Bareground	4.00	4.00	4.00	9.00	4.00	4.00	3.00
Rock	1.00	1.00	1.00	1.00	1.00	1.00	2.00
% COMPOSITION							
Shrubs	14.29	0.00	0.00	0.00	0.00	0.00	0.00
Forbs	71.43	53.85	35.71	71.43	71.43	56.25	61.54
Grasses	14.29	46.15	64.29	28.57	28.57	43.75	38.46
Overstory + Understory	95.00	65.00	70.00	85.00	80.00	105.00	125.00

8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
25.00	10.00	50.00	40.00	15.00	10.00	35.00	0.00	0.00	0.00
10.00	0.00	0.00	25.00	0.00	5.00	0.00	0.00	25.00	0.00
0.00	10.00	10.00	0.00	25.00	15.00	0.00	0.00	0.00	0.00
0.00	0.00	10.00	0.00	0.00	15.00	5.00	5.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00
0.00	20.00	5.00	0.00	0.00	0.00	5.00	0.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	10.00	5.00	15.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	10.00
10.00	10.00	10.00	25.00	5.00	15.00	15.00	10.00	0.00	15.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00
0.00	0.00	5.00	0.00	10.00	0.00	5.00	0.00	0.00	0.00
10.00	0.00	5.00	0.00	0.00	0.00	10.00	0.00	10.00	0.00
0.00	10.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00
10.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	0.00	5.00	25.00	10.00	0.00	10.00	0.00	0.00	0.00
15.00	0.00	5.00	0.00	0.00	0.00	0.00	15.00	0.00	10.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	10.00
10.00	10.00	5.00	10.00	0.00	15.00	5.00	0.00	20.00	15.00
25.00	10.00	50.00	40.00	15.00	10.00	35.00	0.00	0.00	0.00
85.00	70.00	80.00	85.00	60.00	80.00	65.00	60.00	60.00	70.00
10.00	25.00	15.00	10.00	35.00	15.00	25.00	35.00	35.00	25.00
1.00	4.00	4.00	1.00	4.00	4.00	9.00	4.00	4.00	4.00
4.00	1.00	1.00	4.00	1.00	1.00	1.00	1.00	1.00	1.00
11.76	14.29	12.50	29.41	41.67	25.00	0.00	0.00	41.67	0.00
35.29	71.43	68.75	29.41	41.67	56.25	76.92	58.33	25.00	50.00
52.94	14.29	18.75	41.18	16.67	18.75	23.08	41.67	33.33	50.00
110.00	80.00	130.00	125.00	75.00	90.00	100.00	60.00	60.00	70.00

18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00
0.00	50.00	0.00	0.00	0.00	25.00	35.00	0.00	70.00	0.00
0.00	15.00	0.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00
0.00	0.00	10.00	0.00	0.00	20.00	0.00	0.00	10.00	0.00
15.00	0.00	0.00	0.00	10.00	10.00	15.00	10.00	0.00	0.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	5.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	5.00	0.00	0.00	10.00	20.00	0.00	10.00	0.00	30.00
0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	10.00	0.00
10.00	5.00	10.00	10.00	0.00	10.00	10.00	0.00	10.00	0.00
0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	5.00	0.00	0.00	5.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	10.00	0.00	10.00	0.00
0.00	5.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	25.00
25.00	0.00	10.00	0.00	5.00	0.00	10.00	10.00	10.00	20.00
0.00	5.00	10.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	10.00	0.00	0.00	10.00	0.00	0.00
10.00	5.00	10.00	5.00	30.00	10.00	10.00	5.00	5.00	0.00
0.00	50.00	0.00	0.00	0.00	25.00	35.00	0.00	70.00	0.00
70.00	50.00	50.00	60.00	85.00	70.00	65.00	75.00	70.00	75.00
25.00	45.00	45.00	35.00	10.00	25.00	30.00	20.00	25.00	20.00
4.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	1.00
1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.00
0.00	30.00	20.00	16.67	0.00	28.57	0.00	13.33	14.29	0.00
50.00	50.00	20.00	58.33	47.06	57.14	69.23	53.33	64.29	73.33
50.00	20.00	60.00	25.00	52.94	14.29	30.77	33.33	21.43	26.67
70.00	100.00	50.00	60.00	85.00	95.00	100.00	75.00	140.00	75.00

CANYON FUEL
Skyline Mine
Waste Rock Site
Aspen Reference Area
Exposure: 23 deg
Slope: NNW

28.00	29.00	30.00	Mean	SDev	Freq	Sample Date: 1 June 2007
						OVERSTORY
50.00	35.00	20.00	20.17	20.59	63.33	*Populus tremuloides*
						UNDERSTORY
						TREES & SHRUBS
0.00	0.00	0.00	3.67	7.06	26.67	*Populus tremuloides*
0.00	0.00	0.00	3.33	6.62	23.33	*Symphoricarpos oreophilus*
						FORBS
0.00	0.00	0.00	3.33	5.22	33.33	*Achillea millefolium*
0.00	0.00	0.00	0.50	1.98	6.67	*Cynoglossum officinale*
0.00	0.00	0.00	0.17	0.90	3.33	*Erysimum asperum*
25.00	15.00	10.00	9.17	8.37	66.67	*Galium boreale*
0.00	0.00	0.00	1.33	3.64	13.33	*Hackelia patens*
0.00	0.00	5.00	1.50	3.20	20.00	*Hydrophyllum capitatum*
5.00	10.00	25.00	10.50	6.24	86.67	*Lathyrus lanszwertii*
0.00	0.00	0.00	0.33	1.80	3.33	*Mertensia arizonica*
0.00	0.00	0.00	0.50	1.98	6.67	*Osmorhiza depauperata*
0.00	5.00	0.00	0.83	2.27	13.33	*Ranunculus sp.*
0.00	15.00	0.00	3.00	4.58	33.33	*Rudbeckia occidentalis*
0.00	0.00	0.00	1.00	3.00	10.00	*Senecio sp.*
0.00	0.00	0.00	0.67	1.70	13.33	*Taraxacum officinale*
0.00	0.00	0.00	2.00	4.00	20.00	*Thalictrum fendleri*
10.00	0.00	10.00	4.00	6.38	33.33	*Urtica dioica*
						GRASSES
10.00	10.00	0.00	7.50	7.93	56.67	*Bromus carinatus*
0.00	0.00	10.00	4.50	5.22	46.67	*Elymus spicatus*
0.00	0.00	0.00	1.83	3.76	20.00	*Festuca thurberi*
0.00	10.00	10.00	9.00	6.63	83.33	*Poa secunda*
						COVER
50.00	35.00	20.00	20.17	20.59		Overstory
50.00	65.00	70.00	68.67	9.48		Understory
35.00	25.00	20.00	25.33	9.03		Litter
14.00	9.00	9.00	4.63	2.69		Bareground
1.00	1.00	1.00	1.37	0.91		Rock
						% COMPOSITION
0.00	0.00	0.00	10.45	13.12		Shrubs
80.00	69.23	71.43	56.60	15.63		Forbs
20.00	30.77	28.57	32.95	14.15		Grasses
100.00	100.00	90.00	88.83	22.16		Overstory + Understory

TETRA TECH

June 1, 2007

Canyon Fuel Company, LLC
Mr. Gregg A. Galecki, Environmental Engineer
Skyline Mine

Subject: Waste Rock Area Raptor, Northern Goshawk, and Incidental Species Surveys

Dear Mr. Galecki,

The purpose of this letter is to discuss the raptor survey that was conducted by Tetra Tech at the waste rock area near Scofield, Utah on May 21 and 23, 2007.

Raptor, Northern Goshawk, and Incidental Species Surveys

On May 21 and 23, 2007, Tetra Tech biologists (Colleen Trese and Jill Simmons) conducted a one-visit raptor survey (including a Northern goshawk broadcast vocalization survey) within the waste rock area, southeast of the town of Scofield for Canyon Fuel's Skyline Mine. Incidental species observations were also conducted for the presence of threatened, endangered and special status species, management indicator species and important habitat (including elk calving, mule deer fawning, and sage grouse breeding and nesting) and migratory bird use within the project area. Surveys were conducted to support the extension of the current waste rock area and allow for the continuation of use during the summer of 2007.

A comprehensive raptor survey for nests, signs of presence (whitewash, greenery, etc.) and breeding birds was conducted throughout the project area. A Northern goshawk broadcast vocalization survey was also conducted following U.S. Department of the Agriculture (USDA) Forest Service protocols. Recorded goshawk warning calls were broadcast at survey points on calm mornings between sunrise and mid-afternoon. Survey calling points were located approximately every 320 meters apart along survey routes, some closer or farther apart depending on suitable habitat and topography. At each point, a series of three, ten second bouts of calls were played followed by a one-minute period of listening and observation for goshawk response. In the case that a goshawk responded, biologists traveled toward the individual in search of a nest and signs of presence.

Site description and documented wildlife observations, including pictures identifying specific habitat type and/or key observation areas were noted. A list of incidental species observed during surveys is included in the report.

Waste Rock Area **May 21 & 23, 2007**

Throughout the project area, the habitat was characterized by sagebrush, with small stands of aspen and mixed conifer.

The weather on the first day of the survey consisted of partly cloudy skies with 50 to 60 degree temperatures, wind gusts from 0 to 25 miles per hour (mph), and a light drizzle of rain at the end of the survey. The weather on the second day of the survey consisted of clear skies with 35 to 50 degree temperatures and winds from 0 to 5 mph.

Tetra Tech
6178 Stratler Street, Murray, UT 84107
Tel 801.269.8117 Fax 801.269.8308 www.tetratech.com

Raptor surveys with Northern goshawk vocalization surveys were conducted within the designated waste rock area in T13S and R7E Section 4 and Section 5, and along existing access roads within a half mile of the proposed waste rock extension area. No Northern goshawks were observed and no alarm calls were heard. Incidental species heard and seen in response to taped calls included red-tail hawks, American kestrel, ruby-crowned kinglet, American robin, mule deer and hoary marmots. No mule deer fawning or elk calving areas were observed or identified within/adjacent to the waste rock area.

Two red-tail hawks were observed perched and screeching on May 21, 2007 near Survey Point Four, which is within a quarter of a mile of the waste rock area (Map 1 and Photo 1). A nest was located approximately 100 m south of Survey Point Four (Map 1 and Photo 2). There were no signs of activity such as fresh greenery, prey remains, or whitewash in or around the nest. One red-tail hawk was observed perched and screeching on May 23, 2007 near Survey Point Four. An additional nest search was conducted but no other nests were located.

Photo 1: Red-tail hawk near Survey Point Four

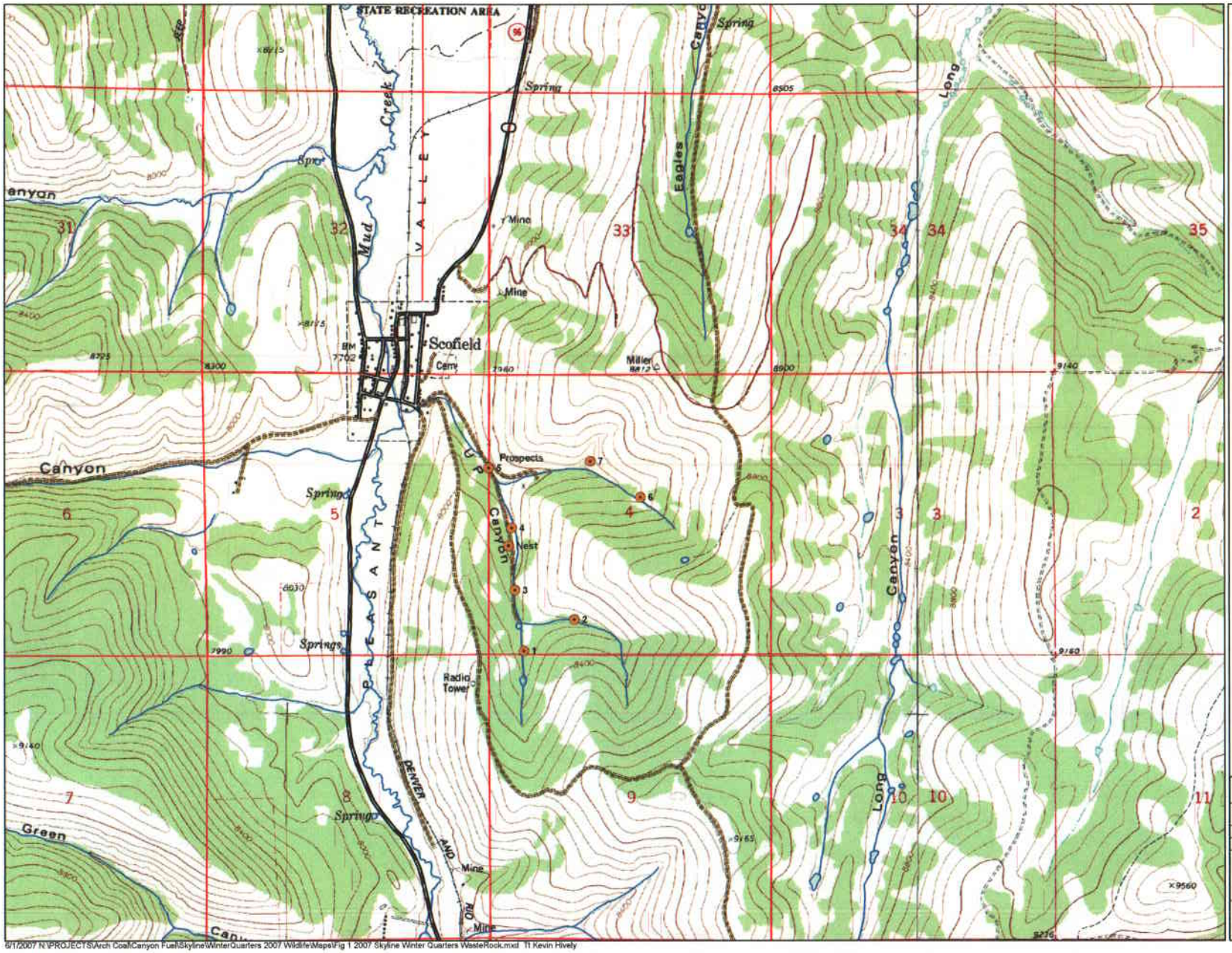
Photo 2: Possible red-tail hawk nest near Survey Point Four

TETRA TECH

Please do not hesitate to contact myself or Jill Simmons with any questions regarding the findings of the survey, at (801) 269-8117.

Sincerely,
Tetra Tech

David Steed
Project Manager/Principle Scientist



6/1/2007 N:\PROJECTS\Arch Coal\Canyon Fuel\Skyline\WinterQuarters 2007 Wildlife\Maps\Fig 1 2007 Skyline Winter Quarters WasteRock.mxd 11 Kevin Hively

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Waste Rock Disposal Site

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(Due to various changes to Section 14 throughout time, pages are not sequential)

Sec. 14

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CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

SEDIMENT FROM AREA 24 A

---

by

Name: GARY E. TAYLOR

Company Name: UTAH FUEL COMPANY
File Name: D:\SEDCAD3\WASTE

Date: 05-04-1994

I, being a professional engineer hereby certify that this map was prepared by me or under my direct supervision and that all information contained thereon is true and correct to the best of my knowledge and information.

Company Name: UTAH FUEL COMPANY
Filename: D:\SEDCAD3\WASTE User: GARY E. TAYLOR
Date: 05-04-1994 Time: 14:21:53
SEDIMENT FROM AREA 24 A
Storm: 2.34 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

GENERAL INPUT TABLE

Specific Gravity: 2.50
Submerged Bulk Specific Gravity: 1.25

Particle Size Distribution(s):

Size (mm)	composite % Finer
4.0000	100.00
2.0000	92.03
1.0000	87.87
0.6000	82.39
0.2500	75.30
0.0750	48.92
0.0320	43.80
0.0160	21.17
0.0080	7.45
0.0040	1.35
0.0020	0.02
0.0010	0.00

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Civil Software Design -- SEDCAD+ Version 3.1

Company Name: UTAH FUEL COMPANY
[redacted]ename: D:\SEDCAD3\WASTE User: GARY E. TAYLOR
Date: 05-04-1994 Time: 14:21:53
SEDIMENT FROM AREA 24 A
Storm: 2.34 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

BS SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
11 1	0.05	64	M	0.026	0.025	0.254	0.0	0.00	0.00
Type: Null Label: AREA 24 A									
11 Structure	0.05							0.00	
11 Total IN/OUT	0.05							0.00	0.00

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Sedimentology-

SED: Sediment
SCp: Peak Sediment Concentration
SSp: Peak Settleable Concentration
24VW: Volume Weighted Average Settleable Concentration - Peak 24 hours
24AA: Arithmetic Average Settleable Concentration - Peak 24 hours

JBS SWS	K	L (ft)	S (%)	CP	Tt (hrs)	PS #	SED (tons)	SCp (mg/l)	SSp (ml/l)	24VW (ml/l)	24AA (ml/l)
M 111 1	0.37	158.3	6.3	0.013	0.025	1	0.0				
Type: Null Label: AREA 24 A											
111 Structure							0.0				
111 Total IN/OUT							0.0	0	0.00	0.00	0.00

9/

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

SILT FENCE FOR ROAD FILL

by

Name: Gary E. Taylor

Company Name: CANYON FUEL CO., SKYLINE MINE
File Name: C:\SEDCAD3\WRDSSILT

Date: 08-10-1998

10/

Civil Software Design -- SEDCAD+ Version 3.1

Company Name: CANYON FUEL CO., SKYLINE MINE
Filename: C:\SEDCAD3\WRDSSILT User: Gary E. Taylor
Date: 08-10-1998 Time: 08:21:55
Silt Fence for Road Fill
Storm: 2.43 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

GENERAL INPUT TABLE

Specific Gravity: 2.50
Submerged Bulk Specific Gravity: 1.25

Particle Size Distribution(s):

Size (mm)	DD Road Fill % Finer
4.0000	100.00
2.0000	85.51
1.0000	82.72
0.6000	79.40
0.2540	68.85
0.0750	32.23
0.0320	23.48
0.0160	8.08
0.0080	2.07
0.0040	0.38
0.0020	0.01
0.0010	0.00

11/

Civil Softwar... 5.1

Company Name: CANYON FUEL CO., SKYLINE MINE
Filename: C:\SEDCAD3\WRDSSILT User: Gary E. Taylor
Date: 08-10-1998 Time: 08:21:55
Silt Fence for Road Fill
Storm: 2.43 inches, 10 year-24 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	0.46*	68	F	0.050	0.000	0.000	0.0	0.01	0.18
		Type: Null Label:								
111	Structure	0.46							0.01	
111	Total IN/OUT	0.46							0.01	0.18

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Sedimentology-

SED: Sediment
SCp: Peak Sediment Concentration
SSp: Peak Settleable Concentration
24VW: Volume Weighted Average Settleable Concentration - Peak 24 hours
24AA: Arithmetic Average Settleable Concentration - Peak 24 hours

	JBS	SWS	K	L (ft)	S (%)	CP	Tt (hrs)	PS #	SED (tons)	SCp (mg/l)	SSp (ml/l)	24VW (ml/l)	24AA (ml/l)
R	111	1	0.24	670.0	0.1	0.900	0.000	1	0.1				
			Type: Null Label:										
	111	Structure							0.1				
	111	Total IN/OUT							0.1	7563	5.71	3.10	0.34

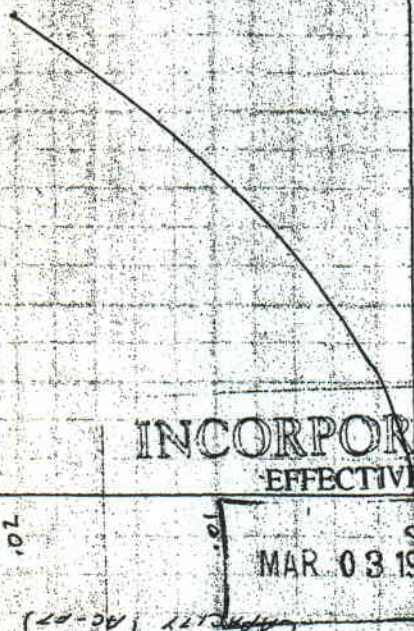
12/

SEDCAD+ BASIN CAPACITY UTILITY

Silt Fence Sediment Trap

ELEVATION	STAGE (ft)	AREA (ac)	CAPACITY (ac-ft)
7835.00	0.00	0.00	0.00
7835.50	0.50	0.00	0.00
7836.00	1.00	0.01	0.00
7836.50	1.50	0.01	0.01
7837.00	2.00	0.01	0.01
7837.50	2.50	0.01	0.02

Capacity Curve

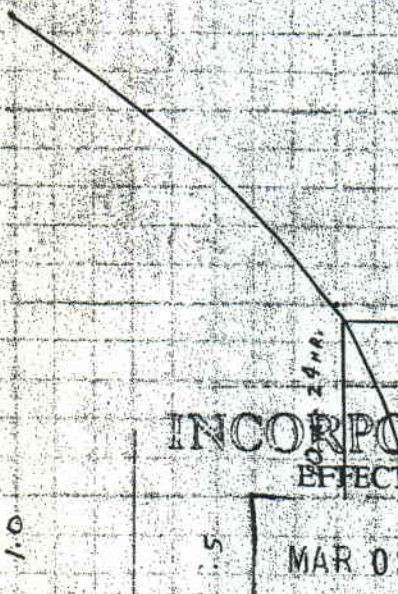


98F

Silt Fence Sediment Trap Discharge

Elevation	Discharge (cfs)	Total Discharge (cfs)
7835	0	0
7835.5	.0668	.0668
7836.0	.1337	.2005
7836.5	.2005	.4010
7837.0	.2674	.6684
7837.5	.3342	1.0026

Discharge Curve



SEDCAD+ RIPRAP CHANNEL DESIGN

DD-16

INPUT VALUES:

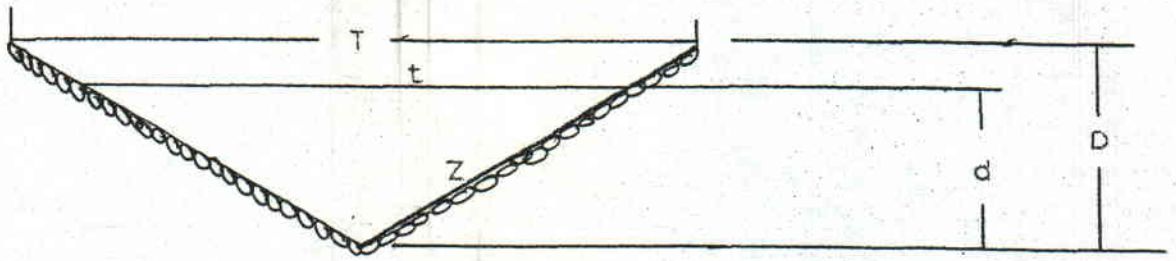
Shape	TRIANGULAR	
Discharge	10.57 cfs	
Slope	12.00 %	
Sideslopes (L and R)	1.00:1	1.00:1
Freeboard	.3 ft	

RESULTS:

Steep Slope Design - PADER Method

Depth	1.27 ft
with Freeboard	1.57 ft
Top Width	2.54 ft
with Freeboard	3.14 ft
Velocity	6.57 fps
Cross Sectional Area	1.61 sq ft
Hydraulic Radius	0.45 ft
Manning's n	0.046
Froude Number	1.45
Dmax	0.625 ft (7.50 in)
D50	0.500 ft (6.00 in)
D10	0.167 ft (2.00 in)

SEDCAD+ CHANNEL DESIGN
DD-16



Riprap - Steep Slope Design - PADER Method

				w/ Freeboard:
Discharge	= 10.57 cfs	Depth (d)	= 1.27	(D = 1.57)
		Top width (t)	= 2.54	(T = 3.14)
Side slopes (Z)	= 1.0:1(L) 1.0:1(R)	Velocity	= 6.57 fps	
Bed Slope	= 12.00 %	Hydraulic Radius	= 0.45 ft	
Manning's n	= 0.046	Froude number	= 1.26	

Dmax = 0.63 ft (7.50 in)
D50 = 0.50 ft (6.00 in)
D10 = 0.17 ft (2.00 in)

SEDCAD+ RIPRAP CHANNEL DESIGN

DD-16A

INPUT VALUES:

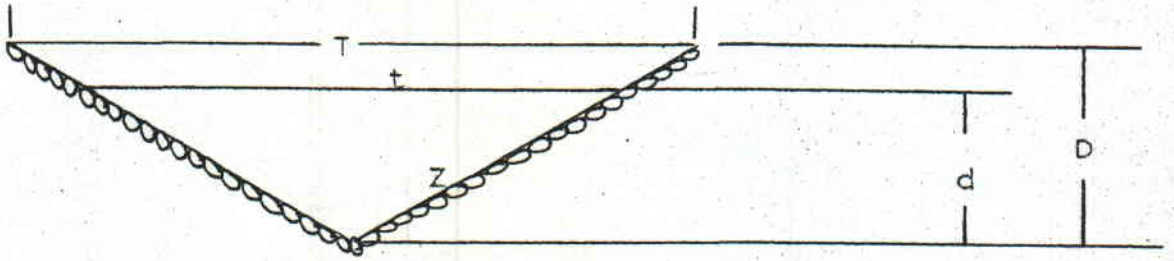
Shape	TRIANGULAR	
Discharge	10.57 cfs	
Slope	36.00 %	
Sideslopes (L and R)	1.00:1	1.00:1
Freeboard	.3 ft	

RESULTS:

Steep Slope Design - PADER Method

Depth	1.08 ft
with Freeboard	1.38 ft
Top Width	2.16 ft
with Freeboard	2.76 ft
Velocity	9.05 fps
Cross Sectional Area	1.17 sq ft
Hydraulic Radius	0.38 ft
Manning's n	0.052
Froude Number	2.17
Dmax	0.938 ft (11.25 in)
D50	0.750 ft (9.00 in)
D10	0.250 ft (3.00 in)

SEDCAD+ CHANNEL DESIGN
DD-16A

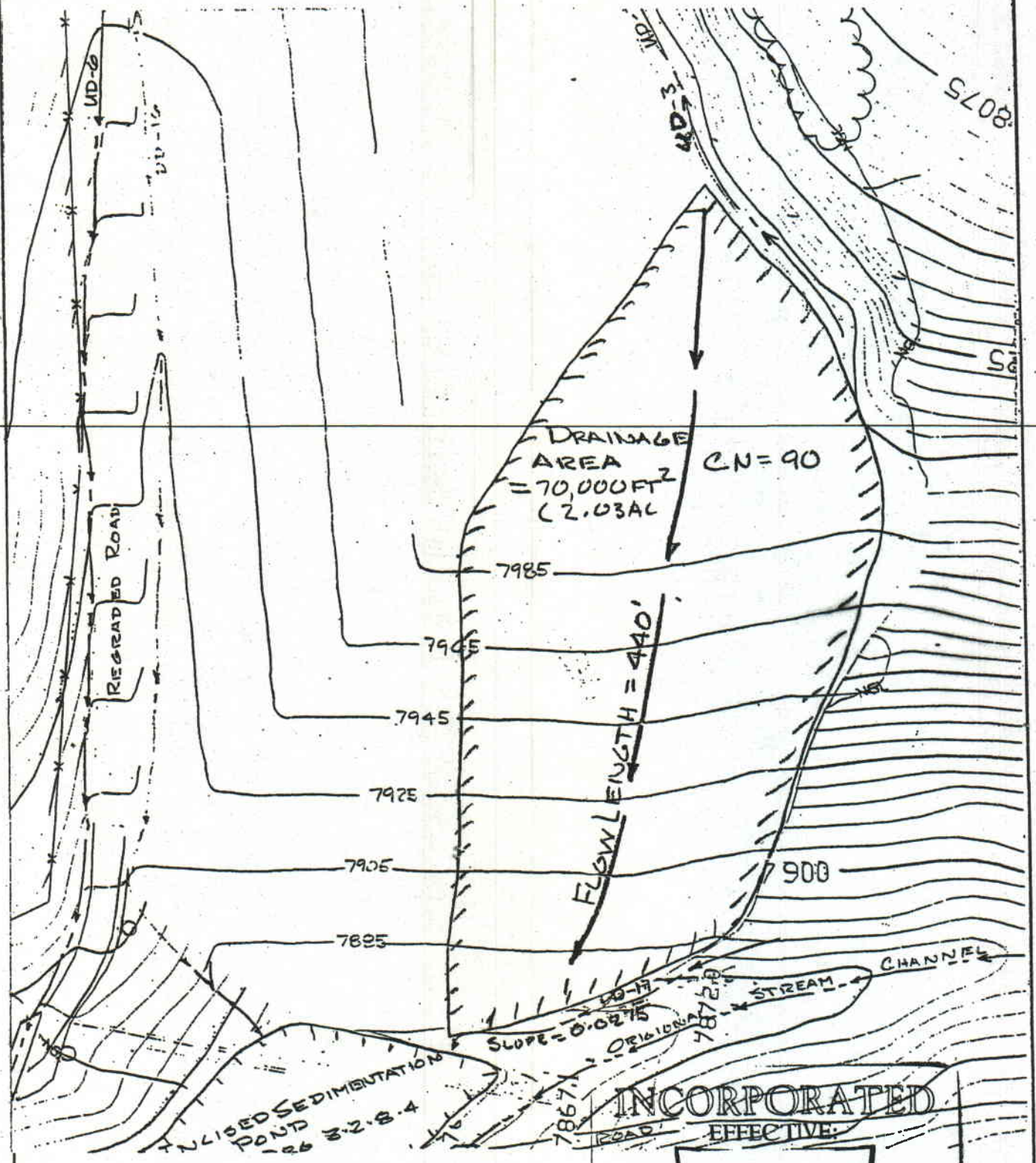


Riprap - Steep Slope Design - PADER Method

					w/ Freeboard:
Discharge	= 10.57 cfs	Depth (d)	=	1.08 (D =	1.38)
		Top width (t)	=	2.16 (T =	2.76)
Side slopes (Z)	= 1.0:1(L) 1.0:1(R)	Velocity	=	9.05 fps	
[redacted] Slope	= 36.00 %	Hydraulic Radius	=	0.38 ft	
[redacted]ning's n	= 0.052	Froude number	=	1.88	

Dmax = 0.94 ft (11.25 in)
D50 = 0.75 ft (9.00 in)
D10 = 0.25 ft (3.00 in)

DISTURBED DRAINAGE DITCH DD-17



III Design DD-17 (1004-6H) Cont.

From TR-55 Table 4-1:

I_a = .222 (CN=90)

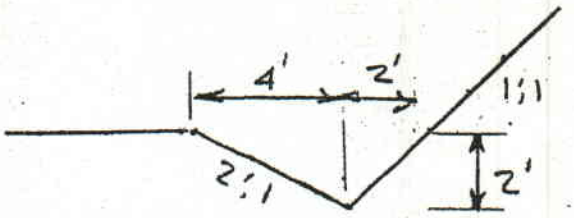
I_a/P = .222/2.25 = 0.098 use 0.1

From TR-55 -- Exhibit 4-III: q_u = 650

$$q_p = 650 \times \frac{2.03}{650} \times 1.311 \times 1$$

q_p = 2.66 cfs

IV Size DD-17



n = 0.04
Q = 2.66
S = 0.0275

Typ Sect

Depth of Flow = 0.78 ft

JHKIVEK, 8-4-93 '97'

IV SIZE DD-17

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: DD-17

Comment: BYPASS DITCH DD-17

Solve For Depth

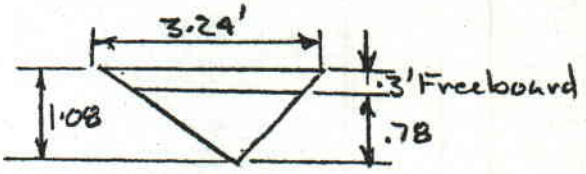
Given Input Data:

Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.0275 ft/ft
Discharge.....	2.66 cfs

Computed Results:

Depth.....	0.78 ft
Velocity.....	2.89 fps
Flow Area.....	0.92 sf
Flow Top Width...	2.35 ft
Wetted Perimeter.	2.86 ft
Critical Depth...	0.72 ft
Critical Slope...	0.0426 ft/ft
Froude Number....	0.81 (flow is Subcritical)

Note: This Ditch has been oversized to 6' wide and 2' deep in order to facilitate Construction and Maintenance, However, the section required to carry the Flow is much smaller as shown



COMPLIANCE SECTION

Open Channel Flow Module, Version 3.41 (c) 1991
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

SEDCAD+ RIPRAP CHANNEL DESIGN

INLET TO POND FROM DD-17

INPUT VALUES:

Shape	TRAPEZOIDAL	
Discharge	2.66 cfs	
Slope	22.00 %	
Sideslopes (L and R)	2.00:1	2.00:1
Bottom Width	8.00 feet	
Freeboard	.3 ft	

RESULTS:

Steep Slope Design - Simons/OSM Method

Depth	0.03 ft
with Freeboard	0.33 ft
Top Width	8.13 ft
with Freeboard	9.33 ft
Velocity	9.97 fps
Cross Sectional Area	0.27 sq ft
Hydraulic Radius	0.03 ft
Manning's n	0.035
Froude Number	9.70
Dmax	0.625 ft (7.50 in)
D50	0.500 ft (6.00 in)
D10	0.167 ft (2.00 in)

29/02

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

HYDROLOGY FOR SW-17

---

by

Name: GARY E. TAYLOR

Company Name: UTAH FUEL COMPANY
File Name: D:\SEDCAD3\WATERSHE

Date: 05-09-1994

Company Name: UTAH FUEL COMPANY
Filename: D:\SEDCAD3\WATERSHE User: GARY E. TAYLOR
Date: 05-09-1994 Time: 06:34:35

HYDROLOGY FOR SW-17

Storm: 2.25 inches, 100 year- 6 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	466.32	70	S	3.383	0.000	0.000	0.0	13.28	16.77
		Type: Null Label: HYDROLOGY FOR SW-17								
111	Structure	466.32							13.28	
111	Total IN/OUT	466.32							13.28	16.77

Note: Drainage area for SW-17 is shown on Drawing 3.2.8-2.

Company Name: UTAH FUEL COMPANY
Filename: D:\SEDCAD3\WATERSHE User: GARY E. TAYLOR
Date: 05-09-1994 Time: 06:34:35

HYDROLOGY FOR SW-17

Storm: 2.25 inches, 100 year- 6 hour, SCS Type II
Hydrograph Convolution Interval: 0.1 hr

DETAILED SUBWATERSHED INPUT/OUTPUT TABLE

J	B	S	SWS	Seg. #	Land Flow Condition	Distance (ft)	Slope (%)	Velocity (fps)	Segment Time (hr)	Time Conc. (hr)	Muskingum K (hr)	Muskingum X
1	1	1	1	-a	1	4562.17	2.19	0.37	3.38	3.383		

PARABOLA DITCH EQUATION

DESIGNED: G. TAYLOR
09-May-94

DITCH NO. SW-17

AREA = 2/3*D*T

HYDRAULIC RADIUS =(2*D*(T^2)/(3*(T^2)+8*(D^2)) ^2/3)

MANNING'S EQUATION

Q = A*(1.486/N)*(R^2/3)*(S^1/2)

Q =(2/3*D*T)*(1.486/N)*((2*D*(T^2)/(3*(T^2)+8*(D^2))) ^2/3)*(S^1/2)

D = DEPTH OF FLOW 0.336 FT.

N = MANNING'S ROUGHNESS COFFICIENT 0.014

T = TOTAL WIDTH OF THE CHANNEL 10.00 FT.

S = SLOPE 0.04 FT./FT.

A = 2.24 SQ. FT.

R = 0.37 FT.

S = 0.20

M = 106.1428

Q = 17.78 CFS

V = 7.94 FPS

REFERENCE

BARFIELD, B. J., R. C. WARNER, AND C. T. HAAN, 1983. APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS, OKLAHOMA TECHNICAL PRESS, STILLWATER, OKLAHOMA.

SIMONS, LI + ASSOCIATES, SURFACE MINING WATER DIVERSION DESIGN MANUAL U.S. DEPARTMENT OF THE INTERIOR, WASHINGTON D.C.

ISRAELSEN, C. E, J. E. FLECHER, F. W. HANS AND E. K. ISRAELSEN, 1984, EROSION AND SEDIMENTATION IN UTAH, UTAH WATER RESEARCH LABORATORY, UTAH STATE UNIVERSITY, LOGAN, UTAH.

CLYDE, C. G., C. E. ISRAELSEN, P. L. PACKER, E. E. FARMER, J. E. FLETCHER E. K. ISRAELSEN, F. W HANS, N. V. RAO, J. HANSEN, 1978, MANUAL OF EROSION CONTROL PRINCIPLES AND PRACTICES, UTAH WATER RESEARCH LABORATORY, UTAH STATE UNIVERSITY, LOGAN, UTAH.

SCHWAB, P. J. AND R. C. WARNER, 1992, SEDCAD + VERSION 3 ! USERS' MANUAL, CIVIL SOFTWARE DESIGN, AMES, IOWA.

SEDCAD+ NONERODIBLE CHANNEL DESIGN

SW-20

INPUT VALUES:

Shape	PARABOLIC
Depth	0.20 ft
Slope	2.00 %
Manning's n	0.015
Material	CONCRETE
Freeboard	.3 ft

RESULTS:

Discharge	0.35 cfs
Depth w/ Freeboard	0.50 ft
Top Width	0.80 ft
with Freeboard	1.26 ft
Velocity	3.31 fps
Cross Sectional Area	0.11 sq ft
Hydraulic Radius	0.11 ft
Froude Number	1.60

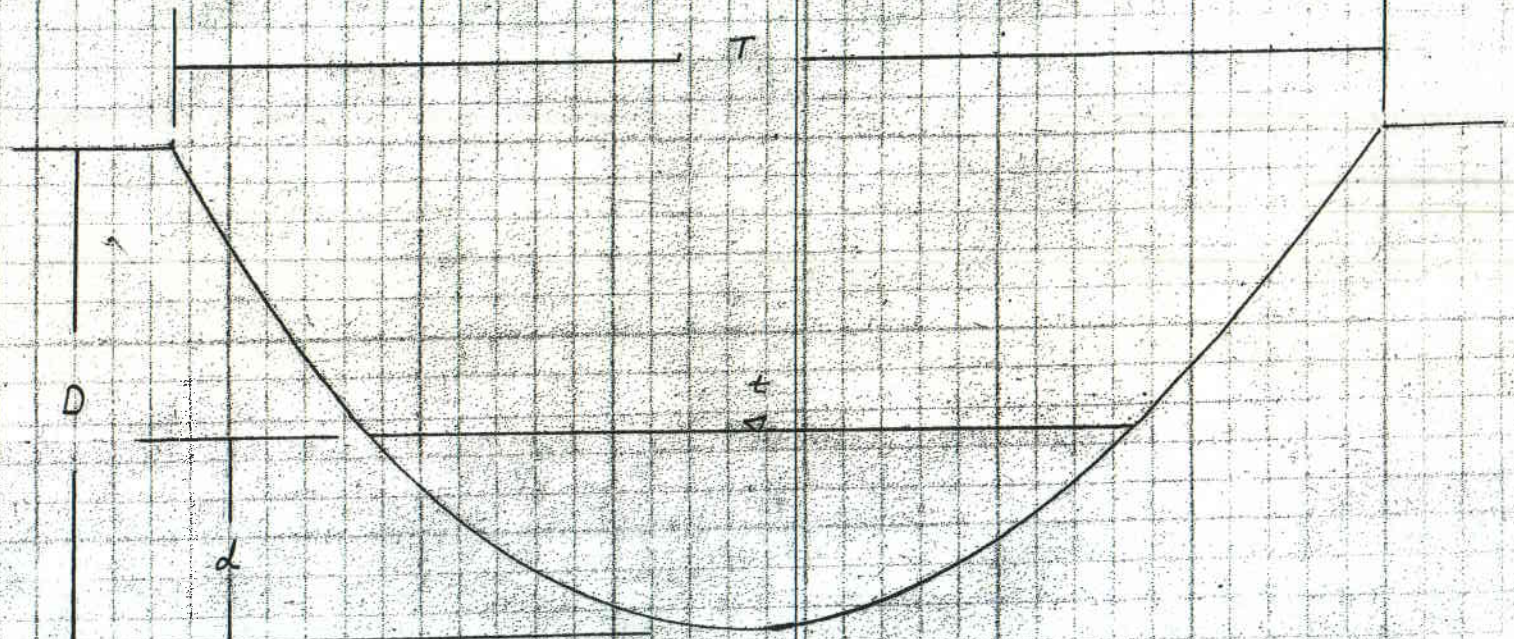
SW-20
CROSS SECTION

DISCHARGE = 0.35 CFS

BED SLOPE = 2%

MANNING'S n = 0.015

DEPTH (d) = 0.2 FT w/FREEBOARD 0.5' FT.
TOP WIDTH (t) = 0.8 FT w/FREEBOARD 1.26 FT
VELOCITY = 3.31 FPS
HYDRAULIC RADIUS = 0.11 FT
FROUDE NUMBER = 1.60



INCORPORATED
EFFECTIVE:

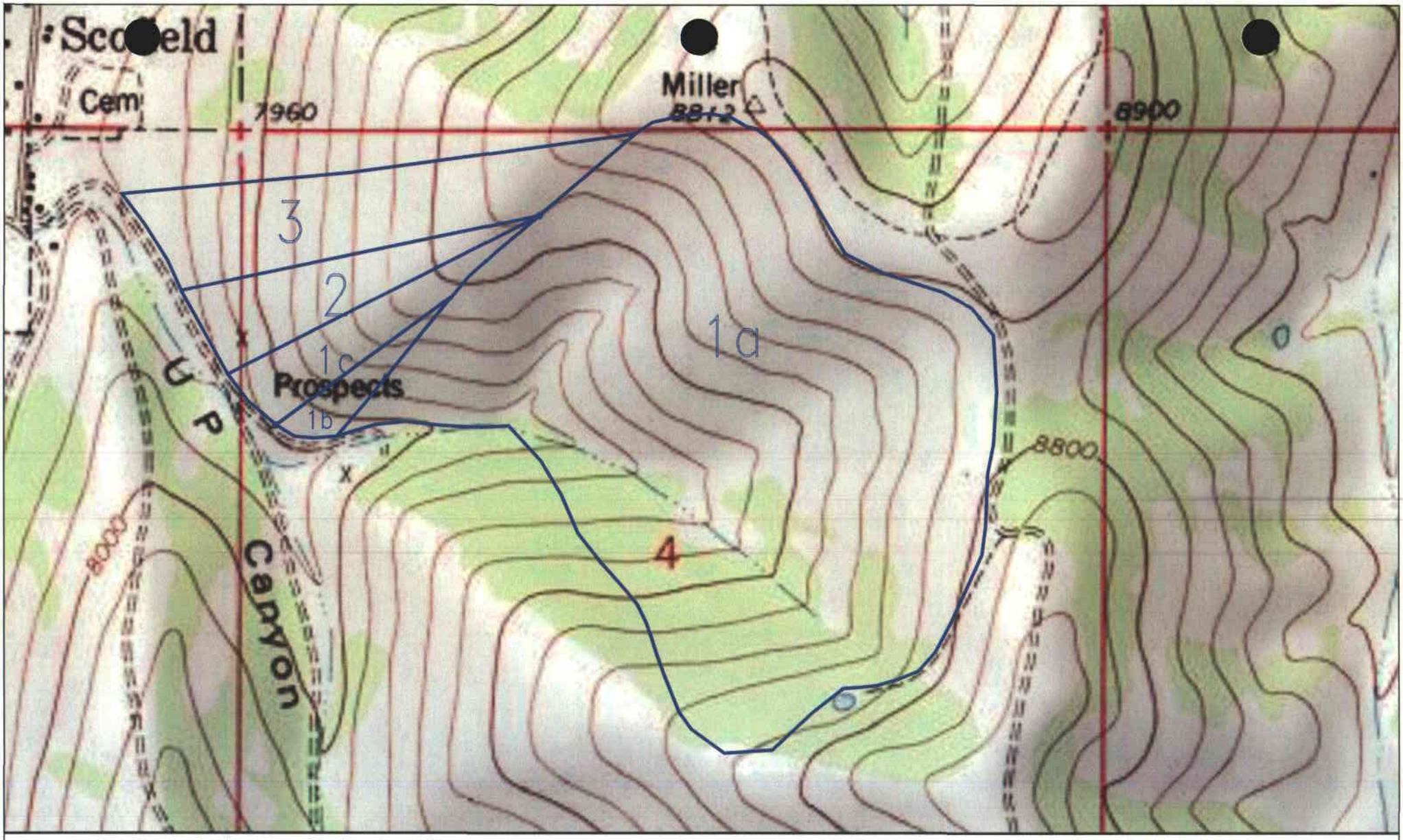
OIL, GAS AND MINING

REFFERENCE INFORMATION FOR THE FOLLOWING SEDCAD 4 DESIGNS

DITCHES: UD-6, DD-14, DD-15
SWALES: SW-13, SW-14, SW-18, SW-19

Design Storm: 10yr – 6 hr, per State Regulation R645-301-742.300
Area Dimensions: per 1:24,000 topographic coverage calculated using AutoCad
Rainfall depth: 1.31 inches. See attached NOAA Atlas 14 data for site specific information
Curve Number: 64. This is the same curve number for the area that was previously in the M&RP. See attached copy of handwritten calculations from M&RP – the page was taken out of the main body of the M&RP because it was no longer relevant in its location. Also included are Table 7-14, (UDOT Manual of Instructions) and Table 5 of Vegetation of the Waste Rock Expansion Site, Mt Nebo Scientific, Inc, June 2007 (See Appendix A-2 Volume 2). Table 7-14 is provided as basis for the weighted curve number. Table 5 is provided as additional field-inspected information to demonstrate not only living cover, but the amount of litter, and rock. These ditches and swales have been functional for 20+ years (1983 – 2007).

Revised: 8/28/07



#	Area in Acres	Estimated Slope	Corresponding Structures
1a	193.99	29%	UD-6 Head - UD-6A, SW-18
1b	4.46	42%	UD-6B (cumulative to 1a)
1c	11.12	33%	UD-6C, SW-19 (cumulative to 1a & 1b)
2	14.17	29%	DD-14, SW-13
3	30.40	28%	DD-15, SW-14

N

600' 200' 0' 400' 800'

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 39.72 N 111.151 W 8106 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Wed Aug 29 2007

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Help | D

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.21	0.26	0.34	0.43	0.51	0.57	0.74	0.93	1.16	1.36	1.70	1.98	2.26	2.97	3.65	4.55	5.28
2	0.17	0.27	0.33	0.44	0.55	0.65	0.72	0.91	1.15	1.44	1.69	2.10	2.45	2.80	3.70	4.54	5.65	6.56
5	0.24	0.37	0.45	0.61	0.76	0.86	0.92	1.13	1.39	1.75	2.05	2.56	2.98	3.42	4.53	5.51	6.86	7.98
10	0.30	0.45	0.56	0.76	0.94	1.06	1.11	1.31	1.60	1.99	2.34	2.92	3.41	3.89	5.19	6.26	7.79	9.06
25	0.39	0.59	0.73	0.99	1.22	1.36	1.41	1.58	1.90	2.33	2.73	3.42	3.99	4.53	6.05	7.23	9.00	10.45
50	0.47	0.71	0.88	1.19	1.47	1.63	1.67	1.83	2.13	2.57	3.02	3.80	4.43	5.00	6.71	7.95	9.89	11.47
100	0.56	0.85	1.06	1.42	1.76	1.95	1.98	2.12	2.38	2.83	3.32	4.18	4.87	5.48	7.37	8.66	10.76	12.47
200	0.67	1.01	1.26	1.69	2.09	2.31	2.33	2.46	2.69	3.08	3.62	4.57	5.32	5.96	8.02	9.35	11.61	13.44
500	0.83	1.27	1.57	2.12	2.62	2.88	2.90	3.02	3.22	3.41	4.01	5.08	5.91	6.57	8.87	10.23	12.69	14.66
1000	0.98	1.50	1.86	2.50	3.09	3.41	3.43	3.53	3.72	3.76	4.31	5.47	6.36	7.04	9.51	10.89	13.48	15.55

Text version of table

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

Rev 8-4-93 WMS

I. SCOFIELD WASTE ROCK EXPANSION, CHANNEL DESIGN FOR DU-5 & UD-6

A. Note: See the total drainage area for this ditch on the attached drawing Sheet 2/6 of these calculations. The total area has been divided into 7 sub areas each having different soils and/or vegetative Types. The following Table lists the seven areas, the Soil Type taken from SCS Maps & survey data of Carbon County, and Curve Numbers (CN) taken from the SCS TR-55 Manual (June 1986). Vegetative Cover Type was determined using on the Ground surveys and aerial Photos.

#	Area - Ft²	% A	#	Soil Type		Veg. Type	CN	CN x % A
1.	374,094	3	115	Trag-Stoney L.	C	Brush-Poor	77	2.31
2.	2,041,590	17	115	" " "	C	Brush-Fair	70	1190
3.	1,455,023	12	115	" " "	C	Brush-Good	65	780
4.	1,430,746	12	115	" " "	C	Brush-Fair	70	840
5.	1,367,985	11	115	" " "	C	Brush-Good	65	715
6.	1,882,035	15	115	" " "	C	Brush-Good	65	975
7.	3,711,195	30	23	Currecanti Fam.	B	Woods-Good	65	1950
								6381

Weighted Curve No = $\frac{6381}{100}$ = 63.81, use CN = 64

98F

TABLE 7-14 — Other Agricultural Lands[1]

Cover Description Cover Type	Hydrologic Condition	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Pasture, grassland, or range — continuous forage for graving [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow — continuous grass — protected from grazing and generally mowed for hay		30	58	71	78
Brush — brush-weed-grass mixture with brush the major element [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30[4]	48	65	73
Woods — grass combination (orchard or tree farm) [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30[4]	55	70	77
Farmsteads — buildings, land, driveways and surrounding lots	—	59	74	82	86

1 Average runoff condition and $I_a = 0.2S$.

2 Poor: < 50% ground cover or heavily grazed with no mulch
Fair: 50% to 75% ground cover and not heavily grazed
Good: > 75% ground cover and lightly or only occasionally grazed

3 Poor: < 50% ground cover
Fair: 50% to 75% ground cover
Good: > 75% ground cover

4 Actual Curve Number is less than 30; use CN = 30 for runoff computations.

5 CNs shown were computed for areas with 50% grass (pasture) cover. Other combinations of conditions may be computed from CNs for woods and pasture.

6 Poor: Forest litter, small trees and brush are destroyed by heavy grazing or regular burning.
Fair: Woods grazed but not burned, and some forest litter covers the soil.
Good: Woods protected from grazing; litter and brush adequately cover soil.

Appendix A-2, Volume 2, Vegetation of the Waste Rock Expansion Site, Mt. Nebo Scientific, Inc., June 2007

Table 5: Mean total cover, composition, standard deviation and sample size at the Skyline Mine Waste Rock Site (2007).

Sagebrush/Grass Reference Area	Mean	Standard Deviation	Sample Size
A. TOTAL COVER			
Understory	64.83	7.24	30
Litter	10.33	5.76	30
Bareground	13.00	7.26	30
Rock	11.83	5.55	30
B. % COMPOSITION			
Shrubs	40.21	19.42	30
Forbs	32.28	16.49	30
Grasses	27.51	16.08	30

Table 6: Woody Species Density of the Skyline Mine Waste Rock Site (2007).

Sagebrush/Grass Reference Area	
Species	**Individuals Per Acre**
Artemisia tridentata	4440.07
Purshia tridentata	204.14
Symphoricarpos oreophilus	459.32
Amelanchier utahensis	255.18
Chrysothamnus viscidiflorus	765.53
TOTAL	6124.23

Design for UD 6, SW 18 & SW 19

Branden Hendriks

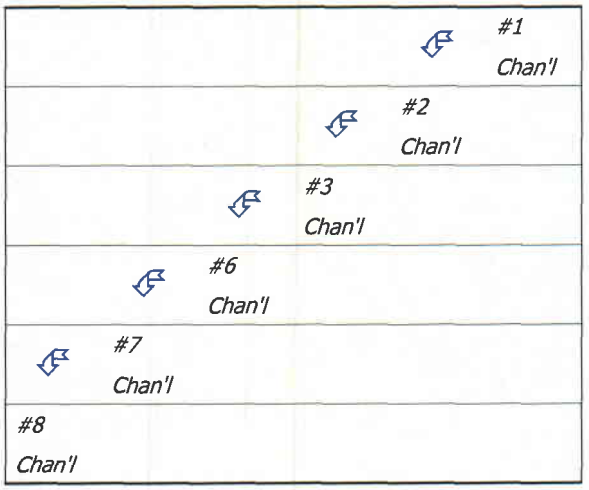
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.310 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#2	0.000	0.000	Head UD6
Channel	#2	==>	#3	0.000	0.000	SW18
Channel	#3	==>	#6	0.000	0.000	UD 6A
Channel	#6	==>	#7	0.000	0.000	UD 6B
Channel	#7	==>	#8	0.000	0.000	UD 6C
Channel	#8	==>	End	0.000	0.000	SW19 SW 19



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	193.990	193.990	0.55	0.08
#2	0.000	193.990	0.55	0.08
#3	0.000	193.990	0.55	0.08
#6	4.460	198.450	0.55	0.08
#7	11.120	209.570	0.59	0.08
#8	0.000	209.570	0.59	0.08

Structure Detail:

Structure #1 (Erodible Channel)

Head UD6

Trapezoidal Erodible Channel Inputs:

Material: Alluvial silts colloidal

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
4.00	2.0:1	2.0:1	9.0	0.0250	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.55 cfs	
Depth:	0.05 ft	0.35 ft
Top Width:	4.21 ft	5.41 ft
Velocity:	2.49 fps	
X-Section Area:	0.22 sq ft	
Hydraulic Radius:	0.052 ft	
Froude Number:	1.92	

Structure #2 (Erodible Channel)

SW18

Trapezoidal Erodible Channel Inputs:

Material: Fine gravel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	6.0:1	6.0:1	6.0	0.0200	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.55 cfs	
Depth:	0.04 ft	0.34 ft
Top Width:	6.51 ft	10.11 ft
Velocity:	2.15 fps	
X-Section Area:	0.26 sq ft	

	w/o Freeboard	w/ Freeboard
Hydraulic Radius:	0.040 ft	
Froude Number:	1.88	

Structure #3 (Erodible Channel)

UD 6A

Trapezoidal Erodible Channel Inputs:

Material: Silt loam noncolloidal

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
4.00	2.0:1	2.0:1	9.0	0.0200	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.55 cfs	
Depth:	0.05 ft	0.35 ft
Top Width:	4.19 ft	5.39 ft
Velocity:	2.90 fps	
X-Section Area:	0.20 sq ft	
Hydraulic Radius:	0.047 ft	
Froude Number:	2.36	

Structure #6 (Erodible Channel)

UD 6B

Trapezoidal Erodible Channel Inputs:

Material: Silt loam noncolloidal

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
2.00	1.0:1	2.0:1	9.0	0.0200	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.55 cfs	
Depth:	0.07 ft	0.37 ft
Top Width:	2.21 ft	3.11 ft
Velocity:	3.66 fps	

	w/o Freeboard	w/ Freeboard
X-Section Area:	0.15 sq ft	
Hydraulic Radius:	0.066 ft	
Froude Number:	2.48	

Structure #7 (Erodible Channel)

UD 6C

Triangular Erodible Channel Inputs:

Material: Graded loam to cobbles when noncolloidal

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	1.0:1	9.0	0.0300	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.59 cfs	
Depth:	0.28 ft	0.58 ft
Top Width:	1.13 ft	2.33 ft
Velocity:	3.74 fps	
X-Section Area:	0.16 sq ft	
Hydraulic Radius:	0.126 ft	
Froude Number:	1.76	

Structure #8 (Erodible Channel)

SW19

SW 19

Trapezoidal Erodible Channel Inputs:

Material: Fine gravel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	6.0:1	6.0:1	6.0	0.0200	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.59 cfs	

	w/o Freeboard	w/ Freeboard
Depth:	0.04 ft	0.34 ft
Top Width:	6.52 ft	10.12 ft
Velocity:	2.18 fps	
X-Section Area:	0.27 sq ft	
Hydraulic Radius:	0.041 ft	
Froude Number:	1.89	

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	193.990	0.193	0.000	0.000	64.000	M	0.55	0.076
	Σ	**193.990**						**0.55**	**0.076**
#2	Σ	**193.990**						**0.55**	**0.076**
#3	Σ	**193.990**						**0.55**	**0.076**
#6	1	4.460	0.042	0.000	0.000	64.000	M	0.02	0.002
	Σ	**198.450**						**0.55**	**0.078**
#7	1	11.120	0.090	0.000	0.000	64.000	M	0.04	0.005
	Σ	**209.570**						**0.59**	**0.084**
#8	Σ	**209.570**						**0.59**	**0.084**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	29.00	870.00	3,000.00	4.300	0.193
#1	**1**	**Time of Concentration:**					**0.193**
#6	1	3. Short grass pasture	42.00	336.00	800.00	5.180	0.042
#6	**1**	**Time of Concentration:**					**0.042**
#7	1	3. Short grass pasture	33.00	495.00	1,500.00	4.590	0.090
#7	**1**	**Time of Concentration:**					**0.090**

Design for DD14 & SW 13

Branden Hendriks

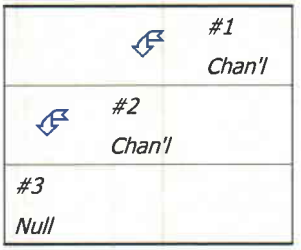
General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.310 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#2	0.000	0.000	DD 14
Channel	#2	==>	#3	0.000	0.000	SW 13
Null	#3	==>	End	0.000	0.000	



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	14.170	14.170	0.05	0.01
#2	0.000	14.170	0.05	0.01
#3	0.000	14.170	0.05	0.01

Structure Detail:

Structure #1 (Erodible Channel)

DD 14

Triangular Erodible Channel Inputs:

Material: Alluvial silts colloidal

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	1.0:1	9.0	0.0250	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.05 cfs	
Depth:	0.10 ft	0.40 ft
Top Width:	0.39 ft	1.59 ft
Velocity:	2.20 fps	
X-Section Area:	0.02 sq ft	
Hydraulic Radius:	0.043 ft	
Froude Number:	1.76	

Structure #2 (Erodible Channel)

SW 13

Trapezoidal Erodible Channel Inputs:

Material: Fine gravel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	6.0:1	6.0:1	4.0	0.0200	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.05 cfs	
Depth:	0.01 ft	0.31 ft
Top Width:	6.12 ft	9.72 ft
Velocity:	0.69 fps	
X-Section Area:	0.06 sq ft	

	w/o Freeboard	w/ Freeboard
Hydraulic Radius:	0.010 ft	
Froude Number:	1.22	

Structure #3 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	14.170	0.064	0.000	0.000	64.000	M	0.05	0.007
	Σ	**14.170**						**0.05**	**0.007**
#2	Σ	**14.170**						**0.05**	**0.007**
#3	Σ	**14.170**						**0.05**	**0.007**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	29.00	290.00	1,000.00	4.300	0.064
#1	**1**	**Time of Concentration:**					**0.064**

Design for DD15 & SW14

Branden Hendriks

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.310 inches

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Channel	#1	==>	#2	0.000	0.000	DD 15
Channel	#2	==>	#3	0.000	0.000	SW 14
Null	#3	==>	End	0.000	0.000	

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)
#1	30.400	30.400	0.11	0.01
#2	0.000	30.400	0.11	0.01
#3	0.000	30.400	0.11	0.01

Structure Detail:

Structure #1 (Erodible Channel)

DD 15

Triangular Erodible Channel Inputs:

Material: Alluvial silts colloidal

Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
3.0:1	1.0:1	9.0	0.0250	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.11 cfs	
Depth:	0.14 ft	0.44 ft
Top Width:	0.55 ft	1.75 ft
Velocity:	2.80 fps	
X-Section Area:	0.04 sq ft	
Hydraulic Radius:	0.062 ft	
Froude Number:	1.87	

Structure #2 (Erodible Channel)

SW 14

Trapezoidal Erodible Channel Inputs:

Material: Fine gravel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)	Limiting Velocity (fps)
6.00	6.0:1	6.0:1	4.0	0.0200	0.30			5.0

Erodible Channel Results:

	w/o Freeboard	w/ Freeboard
Design Discharge:	0.11 cfs	
Depth:	0.02 ft	0.32 ft
Top Width:	6.20 ft	9.80 ft
Velocity:	0.96 fps	
X-Section Area:	0.10 sq ft	

	w/o Freeboard	w/ Freeboard
Hydraulic Radius:	0.016 ft	
Froude Number:	1.32	

Structure #3 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	30.400	0.118	0.000	0.000	64.000	M	0.11	0.014
	Σ	**30.400**						**0.11**	**0.014**
#2	Σ	**30.400**						**0.11**	**0.014**
#3	Σ	**30.400**						**0.11**	**0.014**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	3. Short grass pasture	28.00	504.00	1,800.00	4.230	0.118
#1	**1**	**Time of Concentration:**					**0.118**

Section 15

Waste Rock Disposal
Sediment Pond
&
Disturbed Ditches

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SECTION 15

(Due to various changes to Section 15 throughout time, pages are not sequential)

TABLE OF CONTENTS

VOLUME 5
SECTION 15

(Due to various changes to Section 15 throughout time, pages are not sequential)

12/.31

SEDCAD+ RIPRAP CHANNEL DESIGN

UD-4 SPILLWAY DITCH

INPUT VALUES:

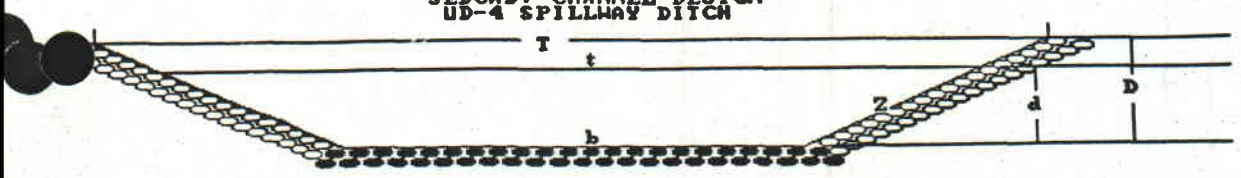
Shape	TRAPEZOIDAL	
Discharge	8.62 cfs	
Slope	34.78 %	
Sideslopes (L and R)	2.00:1	2.00:1
Bottom Width	10.00 feet	
Freeboard	.3 ft	

RESULTS:

Steep Slope Design - PADER Method

Depth	0.18 ft
with Freeboard	0.48 ft
Top Width	10.74 ft
with Freeboard	11.94 ft
Velocity	4.52 fps
Cross Sectional Area	1.91 sq ft
Hydraulic Radius	0.18 ft
Manning's n	0.061
Froude Number	1.89
Dmax	0.313 ft (3.75 in)
D50	0.250 ft (3.00 in)
D10	0.083 ft (1.00 in)

SEDCAD+ CHANNEL DESIGN
UD-4 SPILLWAY DITCH



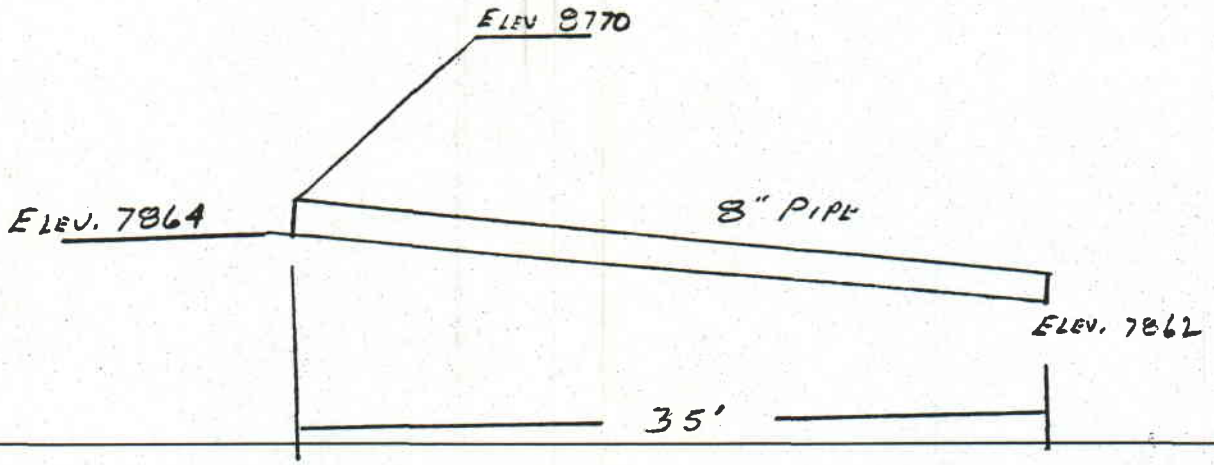
Riprap - Steep Slope Design - PADER Method

						w/ Freeboard:	
Discharge	=	8.62 cfs	Depth (d)	=	0.18 (D =	0.48)	ft
Bottom (b)	=	10.00 ft	Top width (t)	=	10.74 (T =	11.94)	ft
Side slopes (Z)	=	2.0:1(L) 2.0:1(R)	Velocity	=	4.52 fps		
Bed Slope	=	34.70 %	Hydraulic Radius	=	0.16 ft		
Manning's n	=	0.061	Froude number	=	1.89		

Dmax = 0.31 ft (3.75 in)
D50 = 0.25 ft (3.00 in)
D10 = 0.08 ft (1.00 in)

WASTE ROCK DISPOSAL AREA

I DETERMINE DECANT PIPE FLOW



ASSUMPTION:

(1) PIPE IS FLOWING FULL

(2) DISCHARGE END OF THE PIPE IS NOT SUBMERGED.

(3) $n = .014$ CORRUGATED

(4) WATER TIGHT VALVE ON INLET

Note:
Pipe Elevations
Resurved in 2007.
See EarthFax Report

SEDCAD+ CULVERT SIZING UTILITY

DECANT PIPE FROM SEDIMENT POND

Design Discharge	=	3.000 cfs
Entrance Loss Coefficient	=	0.9
Pipe Length	=	35.000 feet
Pipe Slope	=	5.710 %
Manning's n	=	0.014
Maximum Headwater	=	6.000 feet
Tailwater Depth	=	0.000 feet

Smallest Diameter Required to Pass Flow is 8 inches

PERFORMANCE CURVES:

Diameter: 4 inches

Headwater (ft)	Discharge (cfs)	Control	Flow Type
0.60	0.04		0
1.20	0.09	Outlet (Subcritical)	1
1.80	0.13	Outlet (Subcritical)	1
2.40	0.18	Outlet (Subcritical)	1
3.00	0.22	Outlet (Subcritical)	1
3.60	0.27	Outlet (Subcritical)	2
4.20	0.31	Outlet (Subcritical)	2
4.80	0.36	Outlet (Subcritical)	2
5.40	0.40	Outlet (Subcritical)	2
6.00	0.45	Inlet (Supercritical)	3
6.60	0.49	Inlet (Supercritical)	3
7.20	0.54	Inlet (Supercritical)	3
7.80	0.58	Inlet (Supercritical)	3
8.40	0.63	Inlet (Supercritical)	4
9.00	0.67	Inlet (Supercritical)	4

Diameter: 6 inches

Headwater (ft)	Discharge (cfs)	Control	Flow Type
0.60	0.43	Outlet (Subcritical)	2
1.20	0.85	Inlet (Supercritical)	4
1.80	1.07	Inlet	5
2.40	1.19	Inlet	5
3.00	1.30	Inlet	5
3.60	1.42	Inlet	5
4.20	1.53	Outlet	6
4.80	1.65	Outlet	6
5.40	1.76	Outlet	6
6.00	1.88	Outlet	6
6.60	1.99	Outlet	6
7.20	2.05	Outlet	6
7.80	2.11	Outlet	6
8.40	2.17	Outlet	6
9.00	2.23	Outlet	6

Diameter: 8 inches

Headwater (ft)	Discharge (cfs)	Control	Flow Type
0.60	0.74	Inlet (Supercritical)	4
1.20	1.39	Inlet	5
1.80	1.99	Inlet	5
2.40	2.36	Inlet	5
3.00	2.72	Inlet	5
3.60	3.04	Inlet	5
4.20	3.21	Inlet	5
4.80	3.39	Inlet	5
5.40	3.56	Outlet	6
6.00	3.74	Outlet	6
6.60	3.91	Outlet	6
7.20	4.07	Outlet	6
7.80	4.19	Outlet	6
8.40	4.32	Outlet	6
9.00	4.45	Outlet	6

Diameter: 9 inches

Headwater (ft)	Discharge (cfs)	Control	Flow Type
0.60	0.81	Outlet (Subcritical)	2
1.20	1.73	Inlet (Supercritical)	4
1.80	2.42	Inlet	5
2.40	3.00	Inlet	5
3.00	3.41	Inlet	5
3.60	3.83	Inlet	5
4.20	4.15	Inlet	5
4.80	4.42	Inlet	5
5.40	4.68	Outlet	6
6.00	4.94	Outlet	6
6.60	5.14	Outlet	6
7.20	5.32	Outlet	6
7.80	5.51	Outlet	6
8.40	5.69	Outlet	6
9.00	5.87	Outlet	6

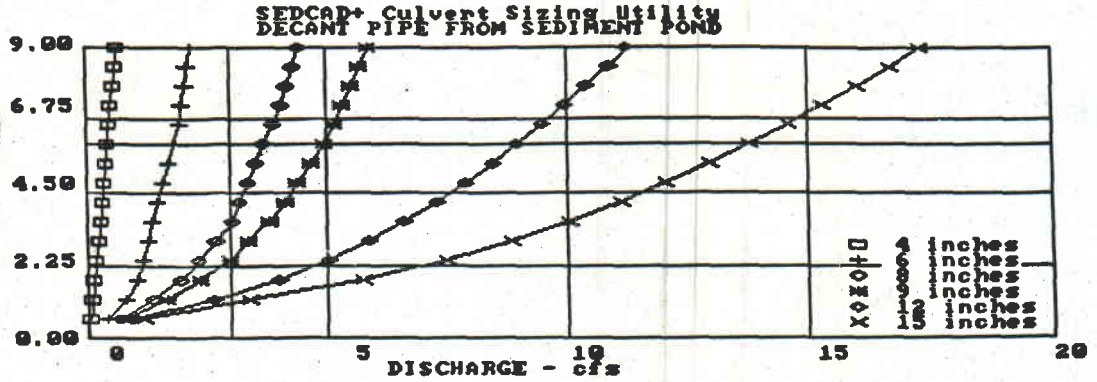
Diameter: 12 inches

Headwater (ft)	Discharge (cfs)	Control	Flow Type
0.60	0.98	Inlet (Supercritical)	3
1.20	2.68	Inlet (Supercritical)	4
1.80	4.05	Inlet	5
2.40	5.06	Inlet	5
3.00	5.89	Inlet	5
3.60	6.61	Inlet	5
4.20	7.28	Inlet	5
4.80	7.89	Inlet	5
5.40	8.44	Inlet	5
6.00	8.98	Inlet	5

6.60	9.46	Inlet	5
7.20	9.94	Inlet	5
7.80	10.39	Inlet	5
8.40	10.82	Inlet	5
9.00	11.21	Inlet	5

Diameter: 15 inches

Headwater (ft)	Discharge (cfs)	Control	Flow Type
0.60	1.24	Inlet (Supercritical)	3
1.20	3.45	Inlet (Supercritical)	3
1.80	5.78	Inlet	5
2.40	7.46	Inlet	5
3.00	8.84	Inlet	5
3.60	10.03	Inlet	5
4.20	11.09	Inlet	5
4.80	12.06	Inlet	5
5.40	12.95	Inlet	5
6.00	13.78	Inlet	5
6.60	14.57	Inlet	5
7.20	15.32	Inlet	5
7.80	16.04	Inlet	5
8.40	16.72	Inlet	5
9.00	17.37	Inlet	5


SEDCAD+ Culvert Sizing Utility
DECANT PIPE FROM SEDIMENT POND
9.00
6.75
4.50
2.25
0.00
0
5
10
15
20
DISCHARGE - cfs
4 inches
6 inches
8 inches
12 inches
15 inches

SEDCAD+ PLUNGE POOL UTILITY

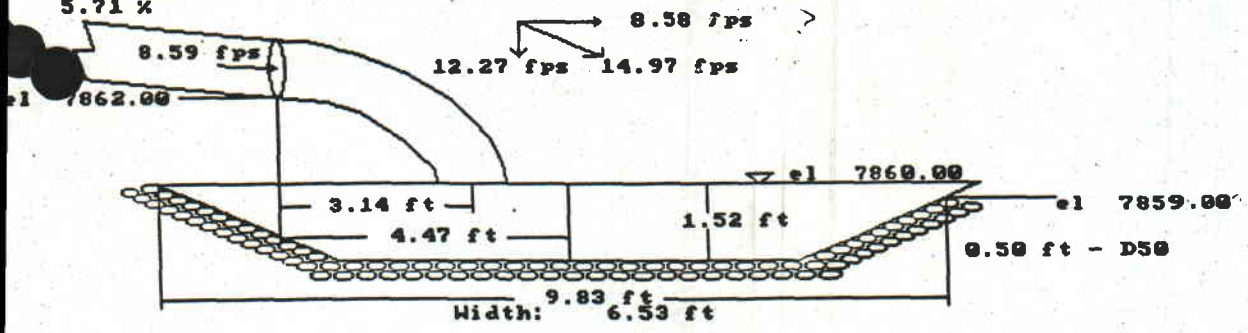
PLUNGE POOL FOR DECANT PIPE

Design Discharge	=	3.00 cfs
Pipe Diameter	=	8.00 in
Pipe Slope	=	5.710 %
Pipe Outlet Elevation	=	7862.00
Tailwater Elevation	=	7860.00
Outlet Crest Elevation	=	7859.00
Rock D50	=	0.50 ft

Pipe Outlet and Tailwater Elevation Difference.....	2.00 feet
Tailwater and Outlet Channel Crest Elevation Difference...	1.00 feet
Required Length of Impact Pool.....	9.83 feet
Required Width of Impact Pool.....	6.53 feet
Depth of Impact Pool from the Tailwater Elevation to the Top of the Rock Riprap.....	1.52 feet
Velocity at Pipe Outlet.....	8.59 fps
Velocity of the Jet Impingement.....	14.97 fps
Horizontal Component of Jet Impingement Velocity.....	8.58 fps
Vertical Component of Jet Impingement Velocity.....	12.27 fps
Froude Number.....	2.90
Horizontal Distance from the Pipe Exit to the Center of the Jet at the Tailwater Surface.....	3.14 feet
Horizontal Distance from the Pipe Exit to the Center of the Plunge Pool.....	4.47 feet

SEDCAD+ PLUNGE POOL DESIGN
PLUNGE POOL FOR DECANT PIPE

3.00 cfs
8.00 inch
5.71 %



SEDCAD+ RIPRAP CHANNEL DESIGN

UD-7 DITCH FROM PLUNGE POOL

INPUT VALUES:

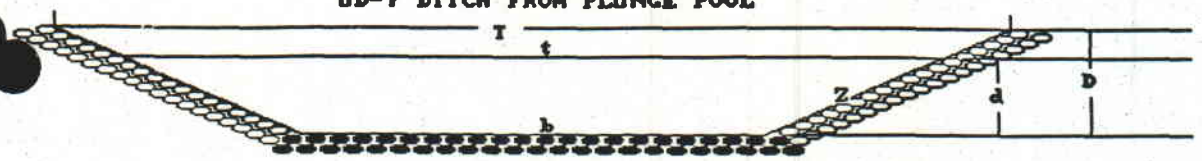
Shape	TRAPEZOIDAL	
Discharge	3.00 cfs	
Slope	7.69 %	
Sideslopes (L and R)	2.00:1	2.00:1
Bottom Width	7.00 feet	
Freeboard	.3 ft	

RESULTS:

Steep Slope Design - Simons/OSM Method

Depth	0.08 ft
with Freeboard	0.38 ft
Top Width	7.33 ft
with Freeboard	8.53 ft
Velocity	5.06 fps
Cross Sectional Area	0.59 sq ft
Hydraulic Radius	0.08 ft
Manning's n	0.030
Froude Number	3.13
Dmax	0.313 ft (3.75 in)
D50	0.250 ft (3.00 in)
D10	0.083 ft (1.00 in)

SEDCAD+ CHANNEL DESIGN
UD-7 DITCH FROM PLUNGE POOL



Riprap - Steep Slope Design - Simons/CSM Method

						w/ Freeboard:	
ischarge	= 3.00 cfs	Depth (d)	=	0.08	(D =	0.38)	ft
ottom (b)	= 7.00 ft	Top width (t)	=	7.33	(T =	8.53)	ft
ide slopes (Z)	= 2.0:1(L) 2.0:1(R)	Velocity	=	5.06	fps		
ed slope	= 7.69 %	Hydraulic Radius	=	0.08	ft		
anning's n	= 0.030	Froude number	=	3.13			

Dmax = 0.31 ft (3.75 in)
D50 = 0.25 ft (3.00 in)
D10 = 0.08 ft (1.00 in)

ANALYSIS OF SEDIMENTATION POND CAPACITY FOLLOWING WASTE ROCK PILE EXPANSION, SKYLINE MINE, SCOFIELD, UTAH

Prepared for

CANYON FUEL COMPANY
Skyline Mine
Scofield, Utah

August 2007

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CHAPTER 1

INTRODUCTION

The Canyon Fuel Company Skyline Mine has plans to expand its waste-rock disposal pile approximately 0.5 mile southeast of the town of Scofield in Carbon County, Utah. This document provides calculations that show how the existing waste rock pile sedimentation pond and its associated drainage ditches may continue to sufficiently contain runoff from the site. This report has been prepared for Canyon Fuels by EarthFax Engineering, Inc., and contains hydrologic analyses to determine runoff and sediment discharge for design storm events. Engineering calculations included as appendices of this document show that the pond and one of the ditches will continue to conform to the applicable criteria outlined in the Utah Administrative Code Title R645-301. The other ditch will require slight modifications, which are discussed within.

CHAPTER 2
LOCATION AND BACKGROUND INFORMATION

2.1 WASTE ROCK PILE DESCRIPTION

The Canyon Fuels Skyline Mine waste rock pile is located approximately 0.5 mile southeast of Scofield, Utah near the bottom of a small ephemeral drainage. The site is a former open pit coal mine that has been filled with waste rock from the active Skyline Mine. The inactive pit has been nearly completely backfilled, and future plans for storing additional waste rock call for expanding the waste rock pile upslope for approximately 120 feet.

Expansion of the waste rock pile will increase the size of the watershed contributing to the pond, but should not significantly increase the area of exposed high erosion/runoff materials. The top of the current waste rock pile is at approximately 8,050 feet. The top of the planned expansion will be at approximately 8,170 feet. Increasing the size of the waste rock pile will increase the contributing watershed area from 17.8 acres to 18.7 acres. Since the outslopes of the pile are contemporaneously covered with topsoil and revegetated during construction, no more than approximately 3 acres of unvegetated waste rock will be exposed at the ground surface. This will minimize runoff and erosion contributing to the pond. The waste rock pile has been constructed this way since the 1980s, and the existing sedimentation pond has never discharged since it was constructed (Galecki, personal comm.).

2.2 DESIGN CRITERIA

The calculations in this report indicate that the pond and one of the drainage ditches that report to it will contain storm runoff and sediment discharge from the expanded waste rock pile as specified in the Utah Administrative Code Titles R645-301-742 and 743. Another drainage

ditch requires slight modifications to conform to these requirements. The requirements include the following criteria:

- The pond must contain the runoff from a 10-year, 24-hour storm event and provide volume for the storage of sediment from its catchment area.
- The pond must safely convey the peak flow from a 25-year, 6-hour storm event.
- Drainage ditches must safely contain the peak flow from a 100-year, 6-hour storm event

In its current configuration, the pond has a total capacity of approximately 61,850 cubic feet (ft^3). A swale along the northwestern edge of the pond serves as a spillway that will adequately pass the design outflow event. Additionally, an 8-inch diameter steel decant pipe has been installed with an inlet near the bottom of the pond. The inlet is kept closed with a butterfly valve, which can be opened to drain the impoundment.

The pond is fed by two drainage ditches. Drainage ditch DD-16 is located along the base of the north side of the waste rock pile, and then descends a short, steep slope to reach the sedimentation pond. The steep section of the DD-16 is a trapezoidal channel that is armored with riprap (D_{50} = 9 inches). The upper section of DD-16 that parallels the access road is a vee-shaped channel that contains no riprap lining. Drainage ditch DD-17 is located along the western side of the waste rock pile. This ditch is vee-shaped, and contains no riprap lining.

CHAPTER 3
HYDROLOGY CALCULATIONS

3.1 METHODS

Storm discharge for the area contributing to the new sedimentation pond was calculated using the Soil Conservation Service curve number methodology as described in the National Engineering Handbook, Section 4 (Mockus, 1972). Design storm magnitudes were taken from the National Oceanic and Atmospheric Administration (NOAA) ATLAS 14 Point Precipitation Frequency Estimates web page (NOAA, 2006). Watershed areas, average slopes, and hydraulic lengths were calculated from large-scale site maps using AutoCAD 2007 software. Runoff curve numbers (CN) for undisturbed areas were based on observed vegetation and soil types as described in the National Resources Conservation Service (NRCS) soil survey map for the area (Jensen and Borchert, 1988). Typical CN values for disturbed areas were taken from Mockus (1972) and from the Utah Department of Transportation (2006). Detailed hydrology calculations are presented in Appendix A.

3.2 HYDROLOGY CALCULATIONS RESULTS

The sedimentation pond is fed by two watersheds. One watershed drains to the north over the waste rock pile into drainage channel DD-16, and one watershed drains to the west over the waste rock pile into drainage channel DD-17. Runoff calculations for both watersheds are summarized in Table 1 and provided in detail in Appendix A. As indicated in Table 1, runoff volumes total 35,036 cubic feet (0.80 acre-foot) for the 10-year, 24-hour event and 20,108 cubic feet (0.46 acre-foot) for the 25-year, 6-hour event.

CHAPTER 4
SEDIMENT VOLUME CALCULATIONS

4.1 METHODS

The sediment yield of the watersheds draining to the pond was calculated using an adaptation of the U.S. Department of Agriculture (USDA) Universal Soil Loss Equation (USLE) that was developed by the Utah Water Research Laboratory (Israelsen et al., 1984). This method assumes that all of the soil mobilized by erosion in the entire catchment area travels downslope to the proposed sediment pond. Thus, the sediment volume predicted by this equation is conservatively high. In the past 20 years, the sedimentation pond has been cleaned out only two or three times (Galecki, personal comm.).

To assist in calculating sediment yield from the area, the contributing watersheds were divided into seven sections based on soil type, vegetation coverage, and slope angle. The average annual sediment yield was then summed for each section to determine the total annual yield of the area draining into the pond. The sections included undisturbed areas with different NRCS soil types, disturbed revegetated areas, and a disturbed non-revegetated area. It was assumed that due to contemporaneous revegetation of the site that a maximum of approximately 3 acres of non-revegetated waste rock would be exposed at any one time. Additional assumptions used in calculating erosion volumes are detailed in Appendix B.

4.2 EROSION VOLUME CALCULATIONS RESULTS

The estimated annual sediment discharges for each of the two watersheds reporting to the sediment pond are summarized in Table 1. Detailed calculations of sediment discharge are presented in Appendix B. The total calculated annual sediment volume reporting to the sedimentation pond is 10,330 ft^3.

CHAPTER 5
SEDIMENTATION POND AND DRAINAGE DITCH HYDRAULICS

5.1 METHODS FOR DETERMINING HYDRAULIC CAPACITY OF THE SEDIMENTATION POND AND DRAINAGE DITCHES

The hydraulic capacities of the existing sedimentation pond and drainage ditches were evaluated by modeling the design storm events with the waste rock pile at its maximum extent. The storage capacity of the sedimentation pond was configured to contain the runoff from a 10-year, 24-hour precipitation event in addition to a sufficient volume of sediment yield. Furthermore, the spillway was designed to convey the peak flow from the 25-year, 6-hour precipitation event that immediately follows the 10-year, 24-hour event. The drainage channels DD-16 and DD-17 were evaluated for peak flow depths and velocities in response to the 100-year, 6-hour precipitation event. The flow calculations considered the type of channel armor (or lack thereof) that is present at the site. The upper segment of DD-16 was assumed to be "self-armored" with $D_{50} = 4$ inch riprap that will likely result from finer materials being washed into the sedimentation pond during discharge events. The waste rock contains a large fraction of coarse materials, which are expected to accumulate in this channel, which is located at the base of the pile. This channel will be closely monitored to see if this assumption is correct. Pond and channel hydraulics were determined with HydroCAD 2005 software using the hydrologic and erosion information discussed in Chapters 2 and 3 of this report. The dimensions of the existing sedimentation pond and the layout of its outlet structures were re-surveyed on April 9, 2007 so that these parameters could be used in the HydroCAD 2005 calculations.

5.2 RESULTS OF SEDIMENTATION POND HYDRAULICS CALCULATIONS

The existing sedimentation pond can sufficiently contain the runoff from the 10-year, 24-hour precipitation event (35,036 ft^3) and will also contain an additional volume of 6,170 ft^3 of

sediment yield. The stage corresponding to 60% of the sediment storage capacity (3,700 ft^3) is 7,857.7 feet elevation, which is the current sediment cleanout level for the pond. This level is approximately 5 inches below the bottom of the pond decant pipe, which is at 7,858.1 feet elevation. The peak stage corresponding to the 100% of the sediment yield volume in addition to the volume of the 10-year, 24-hour precipitation event is 7,862.2 feet elevation. The peak stage corresponding to the 100% of the sediment yield volume in addition to the volume of the 100-year, 6-hour precipitation event is 7,863.9 feet elevation Refer to Table 2 for a summary of the sediment pond design configuration and Appendix C for pond hydraulics calculations.

Raising the elevation of the inlet of the decant pipe will increase the sediment storage capacity of the pond, and will help prevent the decant pipe inlet from being buried by additional sediment. If the bottom of the inlet is raised 1.9 feet from 7,858.1 feet elevation to 7,860.0 feet elevation, the total sediment storage capacity of the pond would increase from 6,170 ft^3 to 20,787 ft^3. This volume exceeds two years of calculated annual sediment yield. The sediment cleanout elevation (the stage corresponding to 60% of the sediment storage volume) would then increase from 7,857.7 feet elevation to 7,859.0 feet elevation. If the decant pipe inlet is raised to 7,860.0 feet elevation, the peak stage corresponding to 100% of the sediment storage capacity (20,787 ft^3) combined with the 10-year, 24-hour precipitation event (35,036 ft^3) would be 7,863.5 feet elevation. This stage is below the elevation of the spillway (7,864.0 feet elevation).

Assuming the pond is initially full to the elevation of the spillway (7,864.0 feet elevation), its peak outflow during the 25-year, 6-hour precipitation event was calculated to be 6.60 cubic feet per second (cfs) at a velocity of 1.3 feet per second (fps). This discharge is low enough to be considered nonerosive, and thus no erosion protection is required on the embankment. The peak stage in this scenario is 7,864.28 feet, which is 0.72 feet below the crest of the embankment.

5.3 RESULTS OF DRAINAGE DITCH HYDRAULICS CALCULATIONS

The hydraulic analysis of the drainage ditches confirms DD-17 will sufficiently contain the design precipitation event, but modifications are required for DD-16 in order for it to contain the design precipitation event. Drainage ditch DD-16, which drains the northern slope of the waste rock pile, was modeled as two segments. An upper segment represented the channel that parallels the access road north of the waste rock pile and a lower segment represented the steep, armored trapezoidal channel that leads from this road down to the sedimentation pond. Drainage ditch DD-17, which drains the western slope of the waste rock pile, was modeled as a single vee-shaped channel.

The peak stage in DD-17 during the design precipitation event was calculated to be 1.03 feet deep with a peak flow velocity of 4.96 feet per second (fps). According to these calculations, this flow is non-erosive and would be safely conveyed by ditch DD-17 without modifications. Refer to Table 3 for a summary of drainage ditch hydraulics and to Appendix C for hydraulics calculations.

Drainage ditch DD-16, however, requires slight modifications in order to successfully convey runoff due to the design precipitation event. Two ditch design alternatives are presented below. The first alternative is to expand upper DD-16 so that it is 1.5 feet deep and 6 feet wide with 2H:1V side slopes. Using this design, the peak stage in the upper segment of DD-16 was calculated to be 1.26 feet deep with a maximum flow velocity of 5.86 fps. The corresponding peak stage in the lower segment of DD-16 was calculated to be 0.27 feet deep with a maximum flow velocity of 6.4 fps. The upper section of drainage ditch DD-16 was assumed to become "self-armored" due to finer particles being transported into the sedimentation pond. This channel will be closely monitored, especially after snowmelt and rain storms, so that appropriate actions

can be taken if excessive erosion occurs. The lower portion of DD-16, which is armored with D_{50} = 9 inch riprap, was calculated to be adequately protected against erosion. Refer to Table 3 for a summary of drainage ditch hydraulics and to Appendix C for hydraulics calculations.

The second alternative is to install a 30 inch diameter corrugated metal or plastic half round pipe along upper DD-16. Using this design, the peak stage in upper DD-16 was calculated to be 0.89 or 1.00 feet deep with a maximum flow velocity of 11.24 or 13.21 fps, if corrugated metal pipe (CMP) or High Density Polyethylene (HDPE) is installed, respectively. The corresponding peak stage in the lower segment of DD-16 was calculated to be 0.29 feet with a peak flow velocity of 6.5 fps for both CMP and HDPE. Refer to Table 3 for a summary of drainage ditch hydraulics and to Appendix C for hydraulics calculations. The high velocity of the water as it leaves upper DD-16 and enters lower DD-16 is sufficient to erode the existing (D_{50} = 9 inch) riprap. Thus, this rip rap must be replaced with D_{50} = 15 inch rip rap or stabilized with concrete grout for a length of at least 6 half round diameters (15 feet) down from the bottom of upper DD-16 and a width of at least 3 half round diameters (8 feet) along the center of lower DD-16 (Thompson et al, 2000).

CHAPTER 6
CONCLUSIONS

This report confirms that the existing sedimentation pond at the Canyon Fuels Skyline Mine waste rock pile will continue to adequately contain precipitation runoff and sediment yield during expansion of the pile for the design events specified in Utah Administrative Code Title R645-301. Drainage ditch DD-17 will also continue to satisfy regulatory requirements. Minor modifications to DD-16, which may include either expanding the upper portion of the channel or installing corrugated half round pipe in the upper portion of the channel and stabilizing some existing riprap in the lower portion of the channel, are detailed in this document. Furthermore, by raising the decant inlet in the sedimentation pond 1.9 feet to an elevation of 7860.0 feet, the pond will be able to contain significantly more sediment yield in addition to the design runoff event.

CHAPTER 7

REFERENCES

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TABLES

Table 1
Summary of Hydrology and Erosion Volume Calculations

Watershed	Area (acres)	Average Soil Conservation Service (SCS) Curve No. (CN)	10-yr, 24-hr Runoff Volume (ft^3)	25-yr, 6-hr Runoff Volume (ft^3)	100-yr, 6-hr Runoff Volume (ft^3)	Annual Sediment Yield (ft^3)
WS-1	14.9	79	27,938	16,034	32,126	10,290
WS-2	3.8	79	7,098	4,074	8,163	40
TOTAL	**18.7**		**35,036**	**20,108**	**40,289**	**10,330**

Note
Refer to Appendices A and B for hydrology and erosion volume calculations, respectively

Table 2
Summary of Sedimentation Pond Hydraulics

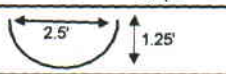
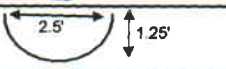
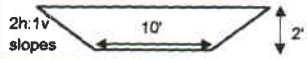
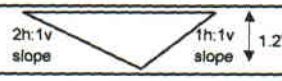
Current bottom of pond elevation (ft)	7,857
Top of embankment elevation (ft)	7,865.0
Existing spillway (swale/weir) elevation[1] (ft)	7,864.0
Decant pipe inlet elevation (ft)	7,858.1
Decant pipe outlet elevation (ft)	7,856.0
Length of decant pipe (ft)	29.0
Current sediment storage volume (ft^3)	6,170
Current sediment storage cleanout elevation (ft)	7,857.7
Current sediment storage cleanout volume (ft^3)	3,702
2 X Annual sediment storage elevation (ft)	7,860.0
Sediment storage volume if decant pipe inlet raised to 7,860.0 feet (ft^3)	20,787
Sediment storage cleanout elevation if decant pipe inlet raised to 7,860.0 feet (ft^3)	7,859.0
Sediment storage cleanout volume if decant pipe inlet raised to 7,860.0 feet (ft^3)	12,463
Current 10-year, 24-hour precipitation event plus 6,170 ft^3 sediment storage peak stage elevation (ft)	7,862.2
10-year, 24-hour precipitation event plus 20,787 ft^3 sediment storage peak stage elevation - assumes decant inlet raised to 7,860.0 feet (ft)	7,863.5
100-year, 6-hour precipitation event plus 20,787 ft^3 sediment storage peak stage elevation - assumes decant inlet raised to 7,860.0 feet (ft)	7,863.9
Spillway design event peak elevation[2] (ft)	7,864.28
Spillway design event peak flow[2] (cfs)	6.6
Spillway design event peak flow velocity[2] (fps)	1.3

Notes:

[1] The existing spillway is a 1 ft deep X 18 ft long X 10 ft broad swale on the top of the pond embankment.

[2] Includes 25-year, 6-hour precipitation event with the pond initially full to the spillway elevation.

Table 3
Summary of Drainage Ditch Hydraulics

Channel	X-section	100yr 6hr Max Flow (cfs)	Avg. Slope (ft/ft)	Max Depth (ft)	Max Vel. (fps)	D_{50} Riprap (in)	Manning's n*
Upper DD-16 (Armored V)		22.3	0.083	1.26	5.86	4	0.050
Upper DD-16 (CMP ½Round)		22.3	0.083	1.00	11.24	none	0.025
Upper DD-16 (HDPE ½Round)		22.3	0.083	0.89	13.21	none	0.020
Lower DD-16		18.53	0.33	0.27	6.4	9	0.054
DD-17		8.1	0.041	1.03	4.96	none	0.034

Upper DD-16 will either be constructed as a rip-rap armored V-shaped channel, or with 30-inch diameter half-round corrugated HDPE or metal pipe. Hydraulic calculations for each of these options are shown in Appendix C.

*Adjusted for riprap size according to USDOT FHWA HEC No. 11 and NUREG/CR 4651, unless no riprap exists (See Appx C). Note that a D_{50} of 4 inches was assumed for upper DD-16, due to the erosion of fines and the raveling of coarse material from the waste rock pile into the ditch.

For upper DD-16, armored V-channel option (1-60 foot deep flows) $n = 0.0395 \times (D_{50})^{1/6}$ where D_{50} (inches) is the mean riprap diameter.

For lower DD-16 (cascading flow) $n = 0.0456 \times (D_{50} \times S)^{0.159}$ where D_{50} (inches) is the mean riprap diameter and S (ft/ft) is the channel slope. Note that if half round pipe is used for upper DD-16, concrete stabilization is required for the upper 15 feet of riprap in lower DD-16.

Calculations assume bottom of channel is graded at a relatively constant slope.

APPENDIX A

Hydrology Calculations

Table A-1
Hydrology Calculations

Storm (Rec. Int. - Duration)	Watershed	Watershed Area (sq. ft.)	Watershed Area (acres)	Precip. P (in)	Hydraulic Length - I (ft)	Avg watershed slope - Y (%)	Duration of stom (hr)	Curve Number (CN)	Potential Max. retention S (in.)	Lag - L (hr)	Time of Concentration - Tc (hr)	Runoff - Q (in)	Runoff Volume - V (ft3)
10-24	WS1	648,910	14.9	1.99	2,056	35.8	24	79	2.66	0.10	0.16	0.52	27,938
10-24	WS2	164,873	3.8	1.99	900	51.9	24	79	2.66	0.042	0.07	0.52	7,098
												TOTAL	**35,036**
25-6	WS1	648,910	14.9	1.58	2,056	35.8	24	79	2.66	0.10	0.16	0.30	16,034
25-6	WS2	164,873	3.8	1.58	900	51.9	24	79	2.66	0.042	0.07	0.30	4,074
												TOTAL	**20,108**
100-6	WS1	648,910	14.9	2.12	2,056	35.8	24	79	2.66	0.10	0.16	0.59	32,126
100-6	WS2	164,873	3.8	2.12	900	51.9	24	79	2.66	0.042	0.07	0.59	8,163
												TOTAL	**40,289**

Notes
Refer to attached figure for locations of watersheds and NRCS soils units
Calculations based on Soil Conservation Service (SCS) Method, National Engineering Handbook Section 4, Chapters 9 & 10 by Victor Mockus, 1972
S = (1000/CN) - 10
L = [(I0.8 (S+1)0.7]/(1900Y0.5)
Tc = 1.67L
Q = (P - 0.2*S)2 / (P + 0.8*S)
V = Area * Q

Average Watershed Slope Calculation (Sum of lengths of contour lines X contour interval / Area)

Operational Conditions

WS1

Contour	Length
7900	295
8000	633
8100	796
8200	470
8300	132
TOTAL	**2,326**
AvgSlope	**35.8%**

WS2

Contour	Length
7900	326
8000	348
8100	182
TOTAL	**856**
Avg Slope	**51.9%**

Table A-1 (continued)
Hydrology Calculations

Operational Conditions: Curve Number Calculations

Hyd Soil Group	B	C
Undist, tree Cover	NA	77
Undist., no tree cover	79	NA
Disturbed, no reveg.	85	NA
Disturbed, reveg.	79	NA

WS1

Area No.	Area (ft2)	CN
1a	304,530	79
1b	130,680	85
2	153,401	77
3	60,300	79
TOTAL	648,911	
Avg CN	**79**	

WS2

Area No.	Area (ft2)	CN
1	151,860	79
2	13,013	79
TOTAL	164,873	
Avg CN	**79**	

Notes

Refer to atached figure for locations of numbered areas

Curecanti soils in hydrologic soil group C (from NRCS soil survey)

Trag soils in hydrologic soil group B (from NRCS soil survey)

Avg CN = (Σ Area$_i$ X CN$_i$)/ Total Watershed Area

Curve Numbers for non disturbed areas from UDOT Manual of Instruction Table 7-14 (no trees = Pasture, poor condition; trees = woods, poor condition). Curve Number for disturbed areas taken from National Engineering Handbook Section 4 Table 9.1 (no reveg. = unpaved road, hard surface, reveg. = pasture/range, poor condition, uncontoured).

EXPANDED WASTE ROCK PILE HYDROLOGY CALCS.

1" = 200'

N

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 39.72 N 111.151 W 8106 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Mon Dec 18 2006

Confidence Limits | Seasonality | Location Maps | Other Info | GIS data | Maps | Help | D

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.14	0.21	0.26	0.34	0.43	0.51	0.57	0.74	0.93	1.16	1.36	1.70	1.98	2.26	2.97	3.65	4.55	5.28
2	0.17	0.27	0.33	0.44	0.55	0.65	0.72	0.91	1.15	1.44	1.69	2.10	2.45	2.80	3.70	4.54	5.65	6.56
5	0.24	0.37	0.45	0.61	0.76	0.86	0.92	1.13	1.39	1.75	2.05	2.56	2.98	3.42	4.53	5.51	6.86	7.98
10	0.30	0.45	0.56	0.76	0.94	1.06	1.11	1.31	1.60	1.99	2.34	2.92	3.41	3.89	5.19	6.26	7.79	9.06
25	0.39	0.59	0.73	0.99	1.22	1.36	1.41	1.58	1.90	2.33	2.73	3.42	3.99	4.53	6.05	7.23	9.00	10.45
50	0.47	0.71	0.88	1.19	1.47	1.63	1.67	1.83	2.13	2.57	3.02	3.80	4.43	5.00	6.71	7.95	9.89	11.47
100	0.56	0.85	1.06	1.42	1.76	1.95	1.98	2.12	2.38	2.83	3.32	4.18	4.87	5.48	7.37	8.66	10.76	12.47
200	0.67	1.01	1.26	1.69	2.09	2.31	2.33	2.46	2.69	3.08	3.62	4.57	5.32	5.96	8.02	9.35	11.61	13.44
500	0.83	1.27	1.57	2.12	2.62	2.88	2.90	3.02	3.22	3.41	4.01	5.08	5.91	6.57	8.87	10.23	12.69	14.66
1000	0.98	1.50	1.86	2.50	3.09	3.41	3.43	3.53	3.72	3.76	4.31	5.47	6.36	7.04	9.51	10.89	13.48	15.55

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

Table 9.1.--Runoff curve numbers for hydrologic soil-cover complexes

(Antecedent moisture condition II, and $I_a = 0.2\ S$)

Land use	Cover Treatment or practice	Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

Source: National Engineering Handbook
Section 4: HYDROLOGY Chap 9: Hydrologic soil-cover complex
by Victor Mockus, 1964, rev 1969

http://www.udot.utah.gov/dl.php/tid=826/save/Chapter%

TABLE 7-14 — Other Agricultural Lands[1]

Cover Description		Hydrologic Condition	Curve Numbers for Hydrologic Soil Group			
Cover Type			A	B	C	D
Pasture, grassland, or range — continuous forage for graving [2]		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow — continuous grass — protected from grazing and generally mowed for hay			30	58	71	78
Brush — brush-weed-grass mixture with brush the major element [3]		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30[4]	48	65	73
Woods — grass combination (orchard or tree farm) [5]		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods[6]		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30[4]	55	70	77
Farmsteads — buildings, land, driveways and surrounding lots		—	59	74	82	86

1 Average runoff condition and $I_a = 0.2S$.

2 Poor: < 50% ground cover or heavily grazed with no mulch
Fair: 50% to 75% ground cover and not heavily grazed
Good: > 75% ground cover and lightly or only occasionally grazed

3 Poor: < 50% ground cover
Fair: 50% to 75% ground cover
Good: > 75% ground cover

4 Actual Curve Number is less than 30; use CN = 30 for runoff computations.

5 CNs shown were computed for areas with 50% grass (pasture) cover. Other combinations of conditions may be computed from CNs for woods and pasture.

6 Poor: Forest litter, small trees and brush are destroyed by heavy grazing or regular burning.
Fair: Woods grazed but not burned, and some forest litter covers the soil.
Good: Woods protected from grazing; litter and brush adequately cover soil.

SOIL SURVEY OF CARBON AREA, UTAH, PARTS OF CARBON AND EMERY COUNTIES

Meters
0 35 70 140

Feet
0 100 200 400 600 800

MAP LEGEND

- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans
- Escarpment, bedrock
- Escarpment, non-bedrock
- Gulley
- Levee
- Slope
- Blowout
- Borrow Pit
- Clay Spot
- Depression, closed
- Eroded Spot
- Gravel Pit
- Gravelly Spot
- Gulley
- Lava Flow
- Landfill
- Marsh or Swamp
- Miscellaneous Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Slide or Slip
- Sinkhole
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Perennial Water
- Wet Spot

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 12

Soil Survey Area: Carbon Area, Utah, Parts of Carbon and Emery Counties
Spatial Version of Data: 1
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
9/30/1997; 10/5/1997

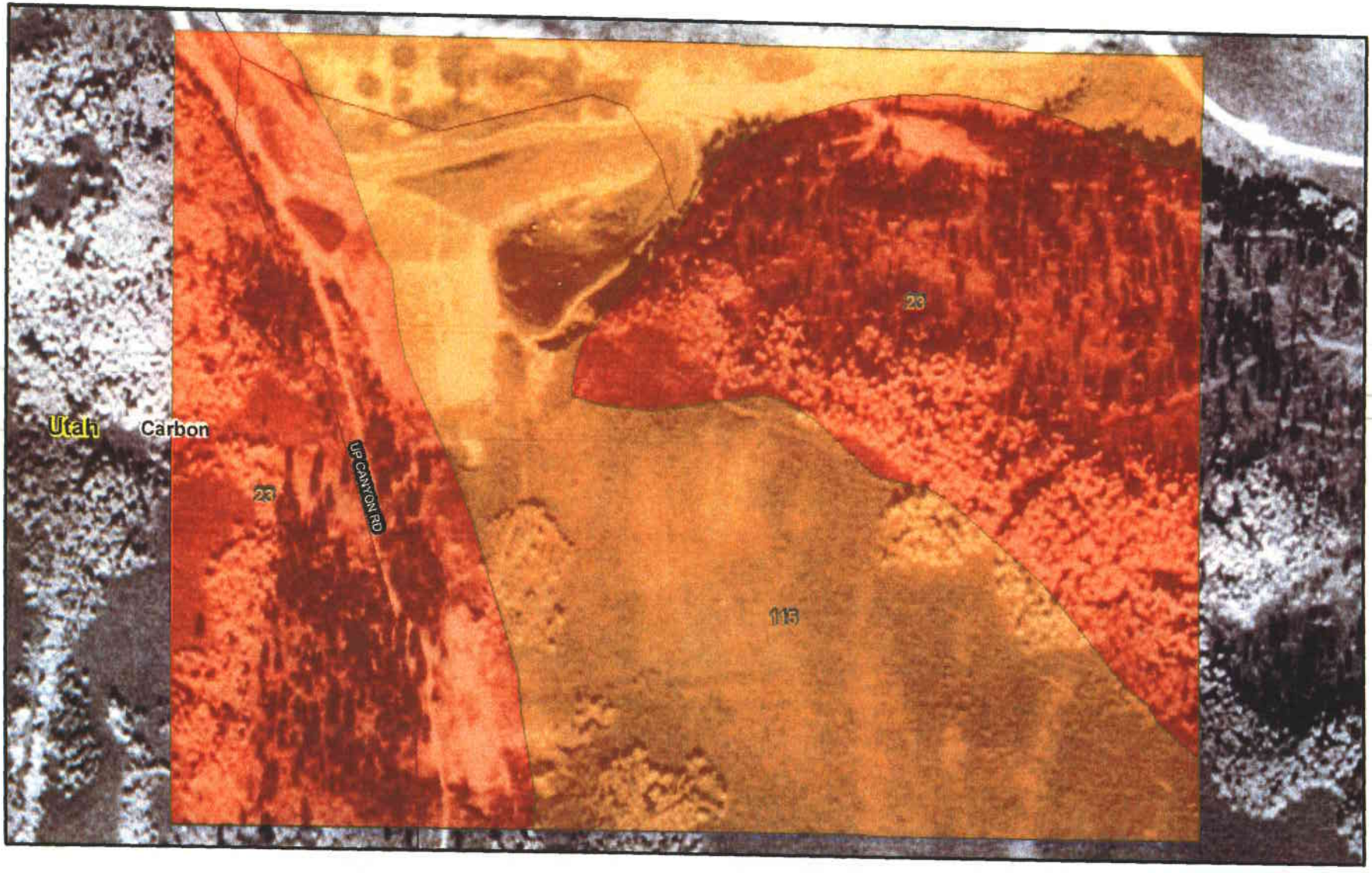
The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend Summary

Carbon Area, Utah, Parts of Carbon and Emery Counties

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
23	Curecanti family-Pathead complex	38.6	52.8
115	Trag stony loam, 30 to 60 percent slopes	34.5	47.2

K FACTOR - WHOLE SOIL RATING FOR CARBON AREA, UTAH, PARTS OF CARBON AND EMERY COUNTIES



Meters
0 35 70 140

Feet
0 100 200 400 600 800

USDA Natural Resources Conservation Service

Web Soil Survey 1.1
National Cooperative Soil Survey

K FACTOR - WHOLE SOIL RATING FOR CARBON AREA, UTAH, PARTS OF CARBON AND EMERY COUNTIES

MAP LEGEND

K Factor - Whole Soil

(Surface Layer), {Dominant Condition, >}

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available
- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 12

Soil Survey Area: Carbon Area, Utah, Parts of Carbon and Emery Counties
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Map comprised of aerial images photographed on these dates:
9/30/1997; 10/5/1997

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables - K Factor - Whole Soil

Summary by Map Unit - Carbon Area, Utah, Parts of Carbon and Emery Counties

Soil Survey Area Map Unit Symbol	Map Unit Name	Rating (K)	HYD SOIL GROUP	Total Acres in AOI	Percent of AOI
23	Curecanti family-Pathead complex	.05	C	38.6	52.8
115	Trag stony loam, 30 to 60 percent slopes	.10	B	34.5	47.2

Description - K Factor - Whole Soil

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Parameter Summary - K Factor - Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff:

Tie-break Rule: Higher

Layer Options: Surface Layer

APPENDIX B

Sediment Yield Calculations

Table B-1
Erosion Calculations

A = R K LS VM
Annual Sediment Volume = A X Area / Soil Density

Area Draining to DD-16	Area No.	Area (ac)	Description	Avg. Slope Y (%)	Slope Length (ft)	Slope Segment Length (ft)	LS	R	K	VM	A (t/ac/yr)	Soil Density (pcf)	Annual Sediment Volume (ft^3)
	1a	2.11	Side of pile: not reveg.	45.0	400	135	45.70	17	0.25	1.00	194.23	84	9,736
	1b	6.99	Side of pile: reveg	45.0	400	135	45.70	17	0.1	0.01	0.78	110	99
	2	0.89	Top of pile	9.5	210	210	1.85	17	0.25	1.48	11.64	84	248
	3	3.52	Undist above pile: Curecant	31.1	900	75	6.08	17	0.05	0.35	1.81	110	116
	4	1.38	Undist above pile: Trag	31.1	900	75	6.08	17	0.1	0.35	3.62	110	91
	TOTAL	14.90											**10,290**

Area Draining to DD-17	Area No.	Area (ac)	Descr.	Avg. Slope Y (%)	Slope Length (ft)	Slope Segment Length (ft)	LS	R	K	VM	A (t/ac/yr)	Soil Density (pcf)	Annual Sediment Volume (ft3)
	5	3.49	Side of Pile: waste rock	51.9	500	500	34.23	17	0.1	0.01	0.58	110	37
	6	0.30	Side slope: undisturbed	51.9	500	500	34.23	17	0.1	0.01	0.58	110	3
	TOTAL	3.78											**40**

GRAND TOTAL	**18.7**	**10,330**

Notes
LS values calculated in Table B-2.
R is taken from isoerodent map of Utah as 17.
K is taken from NRCS soil surveys as 0.05 for Curecanti Family loam, 0.1 for Trag Family, and 0.25 for waste rock based on grain size data from soil samples (HLA Report) and Figure 2 nomograph (Isrealsen, 1984; Wischmeier, 1971). Reclaimed outslopes of pile are assumed to have the K value of the Trag loam (0.1).
VM values are taken from Table 3 (Isrealson et al, 1984) as follows: 0.35 for undisturbed areas (brush), 1.48 for the top of the waste rock pile (compacted fill), 1.0 for pile outslopes (freshly disked soil), and 0.01 for revegetated slopes (permanent >12 mo. seedings). Note that the entire 2:1 outslope of pile reporting to DD-17 and all but three acres of the 2:1 outslope reporting to DD-16 (Area No. 1a) are taken as revegetated.
Soil density assumed to be the saturated density for each soil type (110 pcf for native soil, 84 pcf for waste rock). Density of waste rock taken from soil sample collected from upper waste rock pile in 1998 (HLA, 1998).

Table B-2
LS Calculations for Erosion Calculations

Areas Draining to DD-16 (North)

Undisturbed Area above Pile

slope (%) 27.8
LS (900 foot long slope) 21.05
LS (12 75-ft segments) 6.08

Notes:
LS = ((65.41s^2/s^2+10,000) + 4.56s/(s^2+10,000)^0.5 + 0.065) / (l/72.6)^0.5 for slopes > 5%
s= slope (%), l = length (ft)
Total LS = LS900ft / (No. segments)^0.5 = LS900ft / (12^0.5), as per Isrealson et al, 1984
This calculation assumes that the runoff from this area is primarily directed away from the waste rock pile, either towards (1) the drainage channel along the WRP access road or (2) along the western perimeter of the WRP.

Waste Rock Pile

segment (n)	vertical drop	cum. Vert drop	l_n	λ_n	slope (s)	LS ($s_n\lambda_n$)	LS ($s_n\lambda_{n-1}$)	LS_n	
0	0	0	0	0					
1	20	20	210	210	9.5	1.85	0.00	1.85	
2	200	220	410	620	48.8	42.77	24.89	64.68	45.7

Notes:
Assumes runoff flows down the relatively flat top (segment 1) of the WRP and down the outslope
LS_n for segment 2 has been divided by $2^{0.5}$ due to the presence of the access road which serves to break this slope into 2 parts
ln = length of slope segment (ft).
λn = cumulative length of slope to end of ln (ft)
LS = ((65.41s^2/s^2+10,000) + 4.56s/(s^2+10,000)^0.5 + 0.065) / (l/72.6)^0.5 for slopes > 5%
LSn = (LS(lnsn)ln - LS(ln-1sn)ln-1) / ln
Erosion calculation as per Isrealson et al, 1984

Disturbed Area Draining to DD-17 (West)

slope (%) 45.8%
LS (500 foot long slope) 34.23

Notes:
LS = ((65.41s^2/s^2+10,000) + 4.56s/(s^2+10,000)^0.5 + 0.065) / (l/72.6)^0.5 for slopes > 5%
s= slope (%), l = length (ft)

EXPANDED WASTE ROCK PILE EROSION VOLUME CALCS.

1"=200' ↑N

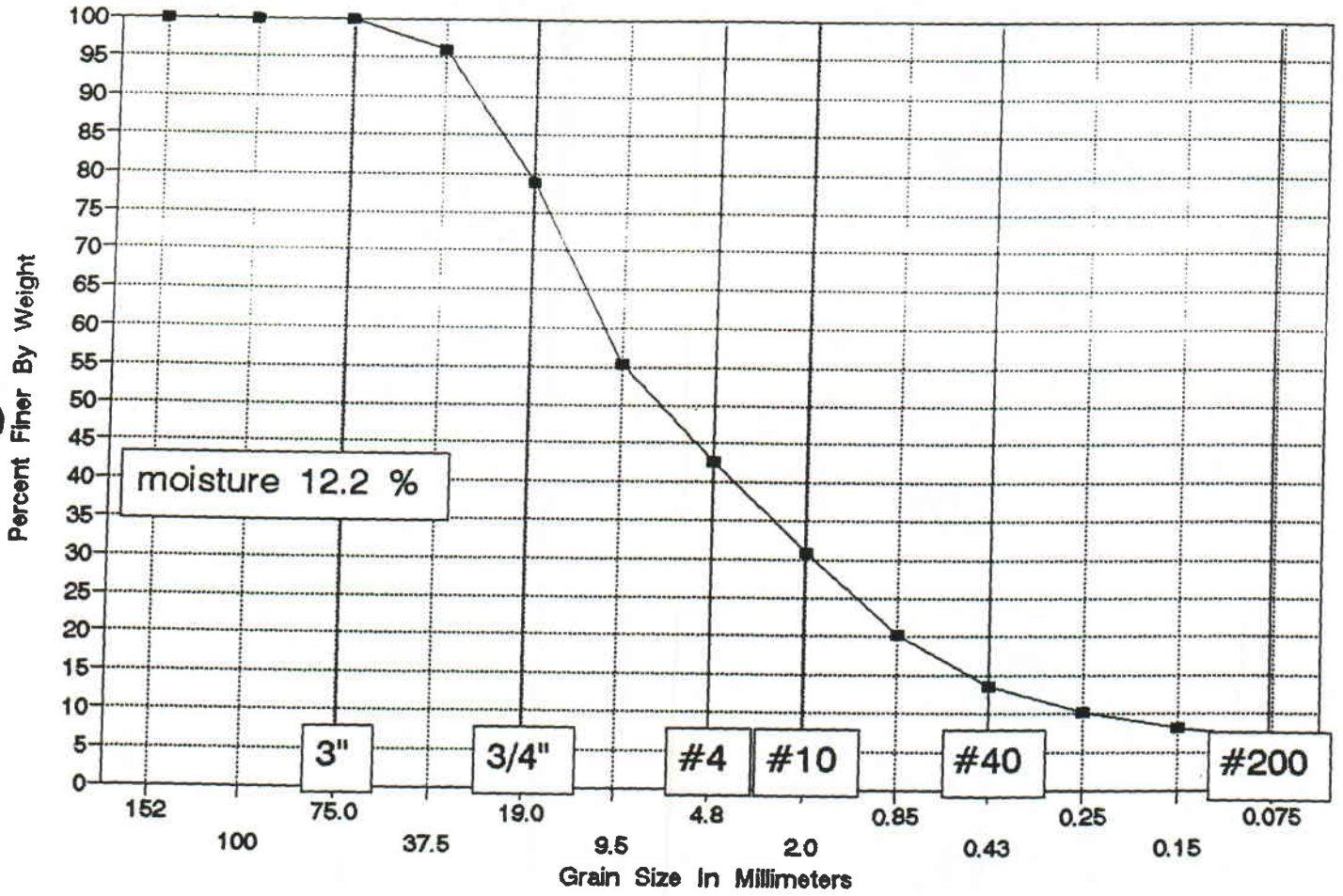
Source: SLOPE STABILITY ANALYSIS OF COAL REFUSE PILE SKYLINE MINE, near the community of SCOFIELD, UTAH

UNPUBLISHED REPORT BY HARDING LAWSON ASSOCIATES

Sept. 1997

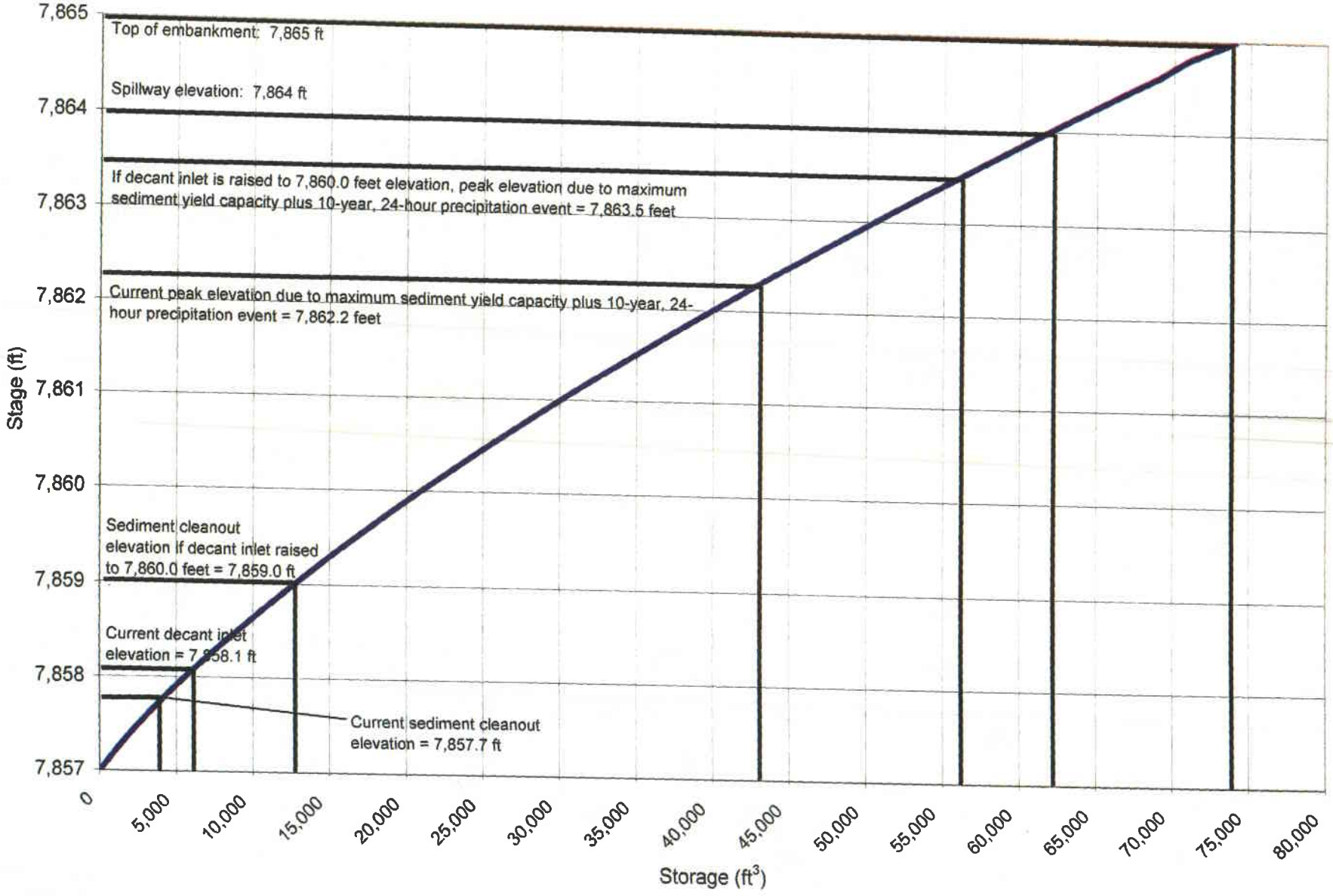
GRADATION CURVE

Bulk Sample #3, Coal Waste

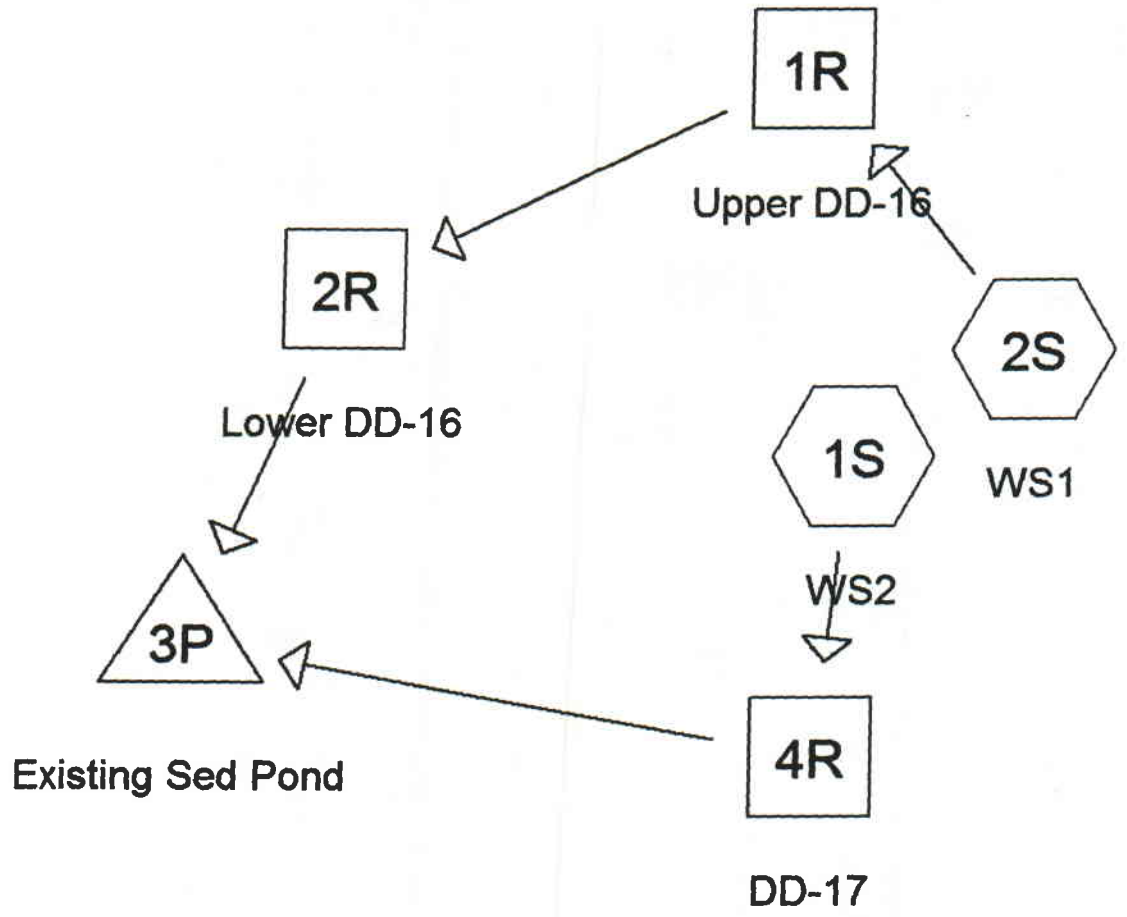


APPENDIX C

Hydraulics Calculations



Sedimentation pond storage vs. elevation curve



Schematic drawing of HydroCAD Model

Subcatchment 2S: WS1

Runoff = 11.04 cfs @ 12.03 hrs, Volume= 0.641 af, Depth= 0.52"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=1.99"

Area (sf)	CN	Description
648,910	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	2,056	0.3580	3.5		**Lag/CN Method,**

Subcatchment 1S: WS2

[49] Hint: Tc<2dt may require smaller dt

Runoff = 3.53 cfs @ 11.96 hrs, Volume= 0.163 af, Depth= 0.52"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr Rainfall=1.99"

Area (sf)	CN	Description
164,873	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	900	0.5190	3.6		**Lag/CN Method,**

Reach 1R: Upper DD-16

Inflow Area = 14.897 ac, Inflow Depth = 0.59"
Inflow = 22.27 cfs @ 3.11 hrs, Volume= 0.738 af
Outflow = 18.30 cfs @ 3.21 hrs, Volume= 0.738 af, Atten= 18%, Lag= 6.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.86 fps, Min. Travel Time= 3.4 min
Avg. Velocity = 1.73 fps, Avg. Travel Time= 11.6 min

peak velocity considered Non-erosive for D_{50} = 4" on 2H:1V channel side slopes acc. to HEC No. 11, FHWA 1978

Peak Storage= 3,830 cf @ 3.16 hrs, Average Depth at Peak Storage= 1.26'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 29.59 cfs

0.00' x 1.50' deep channel, n= 0.050
Side Slope Z-value= 2.0 '/' Top Width= 6.00'
Length= 1,200.0' Slope= 0.0833 '/'
Inlet Invert= 8,010.00', Outlet Invert= 7,910.00'

$n = 0.0395 (D_{50})^{1/6}$

where D_{50} is the mean particle size in inches (assume 4") for submerged riprap (Abt. et al, 1987)

Reach 7R: Upper DD-16 HDPE

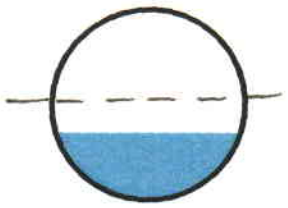
[52] Hint: Inlet conditions not evaluated → inlet conditions not applicable for half round pipe

Inflow Area = 14.897 ac, Inflow Depth = 0.59"
Inflow = 22.27 cfs @ 3.11 hrs, Volume= 0.738 af
Outflow = 20.22 cfs @ 3.16 hrs, Volume= 0.738 af, Atten= 9%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 13.21 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 4.99 fps, Avg. Travel Time= 4.0 min

Peak Storage= 1,879 cf @ 3.13 hrs, Average Depth at Peak Storage= 0.89'
Bank-Full Depth= 2.50', Capacity at Bank-Full= 76.96 cfs

30.0" Diameter Pipe, n= 0.020 Corrugated PE, corrugated interior
Length= 1,200.0' Slope= 0.0833 '/'
Inlet Invert= 8,010.00', Outlet Invert= 7,910.00'



30" ϕ corrugated HDPE half round pipe

Reach 5R: Upper DD-16 CMP

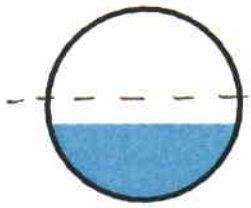
[52] Hint: Inlet conditions not evaluated → inlet conditions Not applicable for ½ round pipe

Inflow Area = 14.897 ac, Inflow Depth = 0.59"
Inflow = 22.27 cfs @ 3.11 hrs, Volume= 0.738 af
Outflow = 20.02 cfs @ 3.17 hrs, Volume= 0.738 af, Atten= 10%, Lag= 3.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.24 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 4.05 fps, Avg. Travel Time= 4.9 min

Peak Storage= 2,191 cf @ 3.13 hrs, Average Depth at Peak Storage= 1.00'
Bank-Full Depth= 2.50', Capacity at Bank-Full= 61.57 cfs

30.0" Diameter Pipe, n= 0.025 Corrugated metal
Length= 1,200.0' Slope= 0.0833 '/'
Inlet Invert= 8,010.00', Outlet Invert= 7,910.00'



30" ϕ Corrugated Metal half round pipe

Reach 2R: Lower DD-16

Assumes V-channel in Upper DD-16

Inflow Area = 14.897 ac, Inflow Depth = 0.59"
Inflow = 18.53 cfs @ 3.21 hrs, Volume= 0.738 af
Outflow = 18.18 cfs @ 3.22 hrs, Volume= 0.738 af, Atten= 2%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.40 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.99 fps, Avg. Travel Time= 1.1 min

peak velocity considered non-erosive for D_{50}=9" on 2H:1V channel side slopes acc. to HEC No.11, FHWA 1978

Peak Storage= 390 cf @ 3.21 hrs, Average Depth at Peak Storage= 0.27'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 577.22 cfs

10.00' x 2.00' deep channel, n= 0.054
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 135.0' Slope= 0.3333 '/'
Inlet Invert= 7,910.00', Outlet Invert= 7,865.00'

$n = 0.0456 (D_{50} \times S)^{0.159}$
where D_{50} is in inches
S is channel slope (0.33)
for cascading flow
from Abt et al, 1987

‡

Reach 2R: Lower DD-16

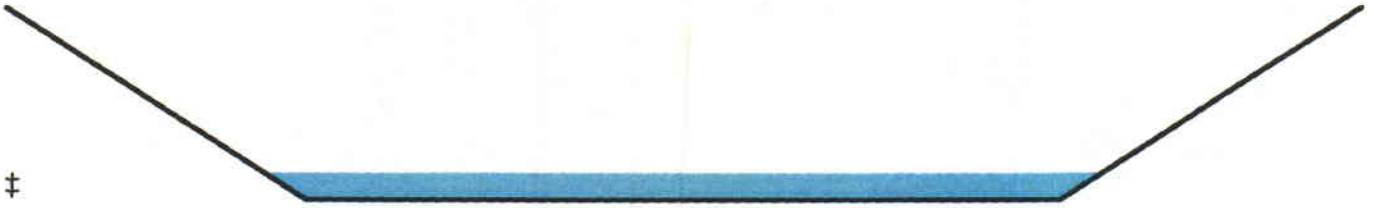
Assumes HDPE ½ round in upper DD-16

Inflow Area = 14.897 ac, Inflow Depth = 0.59"
Inflow = 20.22 cfs @ 3.16 hrs, Volume= 0.738 af
Outflow = 19.77 cfs @ 3.17 hrs, Volume= 0.738 af, Atten= 2%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.61 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.21 fps, Avg. Travel Time= 1.0 min

Peak Storage= 412 cf @ 3.16 hrs, Average Depth at Peak Storage= 0.29'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 577.22 cfs

10.00' x 2.00' deep channel, n= 0.054
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 135.0' Slope= 0.3333 '/'
Inlet Invert= 7,910.00', Outlet Invert= 7,865.00'



Reach 2R: Lower DD-16

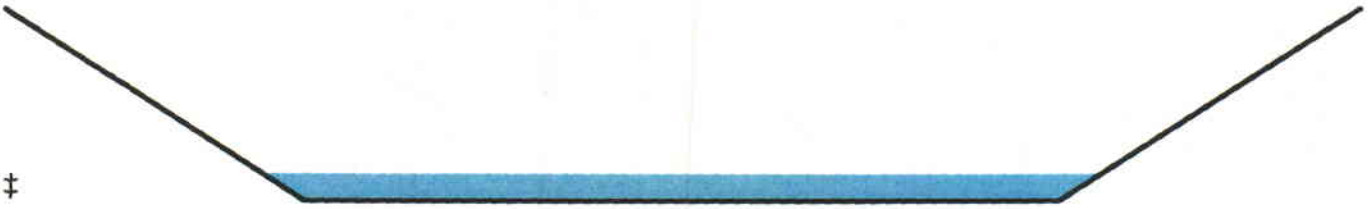
Assumes CMP ½ Round in upper DD-16

Inflow Area = 14.897 ac, Inflow Depth = 0.59"
Inflow = 20.02 cfs @ 3.17 hrs, Volume= 0.738 af
Outflow = 19.50 cfs @ 3.17 hrs, Volume= 0.738 af, Atten= 3%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.54 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.15 fps, Avg. Travel Time= 1.0 min

Peak Storage= 409 cf @ 3.17 hrs, Average Depth at Peak Storage= 0.29'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 577.22 cfs

10.00' x 2.00' deep channel, n= 0.054
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 135.0' Slope= 0.3333 '/'
Inlet Invert= 7,910.00', Outlet Invert= 7,865.00'



Reach 4R: DD-17

Inflow Area = 3.785 ac, Inflow Depth = 0.59"
Inflow = 8.10 cfs @ 3.04 hrs, Volume= 0.187 af
Outflow = 6.66 cfs @ 3.08 hrs, Volume= 0.187 af, Atten= 18%, Lag= 2.4 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.96 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.86 fps, Avg. Travel Time= 3.3 min

peak velocity ≤5.0 fps, considered non-erosive, No armor req'd

Peak Storage= 591 cf @ 3.05 hrs, Average Depth at Peak Storage= 1.03'
Bank-Full Depth= 1.20', Capacity at Bank-Full= 11.86 cfs

0.00' x 1.20' deep channel, n= 0.034
Side Slope Z-value= 1.0 2.0 '/' Top Width= 3.60'
Length= 370.0' Slope= 0.0405 '/'
Inlet Invert= 7,880.00', Outlet Invert= 7,865.00'

Pond 3P: Existing Sed Pond

Inflow Area =	18.682 ac,	Inflow Depth =	0.30"	
Inflow =	9.22 cfs @	3.19 hrs, Volume=	0.462 af	
Outflow =	6.69 cfs @	3.28 hrs, Volume=	0.462 af,	Atten= 28%, Lag= 5.4 min
Primary =	6.69 cfs @	3.28 hrs, Volume=	0.462 af	

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 7,864.00' Surf.Area= 11,792 sf Storage= 61,854 cf
Peak Elev= 7,864.28' @ 3.28 hrs Surf.Area= 11,978 sf Storage= 65,172 cf (3,318 cf above start)
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 12.2 min (247.6 - 235.4)

Volume	Invert	Avail.Storage	Storage Description
#1	7,857.00'	73,982 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
7,857.00	4,488	300.0	0	0	4,488
7,858.00	6,582	346.0	5,502	5,502	6,875
7,860.00	8,755	388.0	15,285	20,787	9,435
7,862.00	10,279	417.0	19,014	39,801	11,460
7,864.00	11,792	444.0	22,054	61,854	13,500
7,865.00	12,466	454.0	12,127	73,982	14,344

Device	Routing	Invert	Outlet Devices
#1	Primary	7,864.00'	**18.0' long x 10.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=6.60 cfs @ 3.28 hrs HW=7,864.28' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 6.60 cfs @ 1.3 fps)

Pond 3P: Existing Sed Pond

Inflow Area = 18.682 ac, Inflow Depth = 0.59"
Inflow = 20.77 cfs @ 3.20 hrs, Volume= 0.925 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Starting Elev= 7,860.00' Surf.Area= 8,755 sf Storage= 20,787 cf
Peak Elev= 7,863.93' @ 26.60 hrs Surf.Area= 11,740 sf Storage= 61,075 cf (40,288 cf above start)
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	7,857.00'	73,982 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
7,857.00	4,488	300.0	0	0	4,488
7,858.00	6,582	346.0	5,502	5,502	6,875
7,860.00	8,755	388.0	15,285	20,787	9,435
7,862.00	10,279	417.0	19,014	39,801	11,460
7,864.00	11,792	444.0	22,054	61,854	13,500
7,865.00	12,466	454.0	12,127	73,982	14,344

Device	Routing	Invert	Outlet Devices
#1	Primary	7,864.00'	**18.0' long x 10.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=7,860.00' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

NUREG/CR-4651
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Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase I

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**Prepared for
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Commission**

4.3.1 Estimating Manning's n for Cascading Flow

The average Manning's roughness value, n, was computed for each failure test based on flow velocities and depths measured prior to failure, and are plotted versus the median stone size, D_{50}, in Fig. 4.7. It is observed in Fig. 4.7 that the n values for 1% and 2% slopes fall closely to the solid line representing a relationship developed by Anderson et al. (see Section 4.3.2). However, the n value for each stone size increased as the slope of the embankment increased, and the n value is over 40% higher when $Depth/D_{50} < 2$ (cascading flow conditions) than when $Depth/D_{50}$ is greater than 2 (Table 4.8).

A median stone size-slope parameter ($D_{50} \times S$) was correlated to the Manning's n value for the CSU data as presented in Fig. 4.8. Combining the median stone size and slope in one parameter appears to have reduced the data scatter. The relationship can be expressed as:

$$n = 0.0456 \, (D_{50} \times S)^{0.159} \qquad (4.8)$$

where D_{50} is in inches. The correlation coefficient, r^2, is 0.90. Therefore, a Manning's n value can be estimated for a riprapped surface in cascading flow as a function of the median stone size and slope.

4.3.2 Comparison of Procedures

A commonly used expression for determining Manning's n for riprap was presented by Anderson et al. (1970) as

$$n = 0.0395\ (D_{50})^{1/6} \qquad (4.9)$$

where D_{50} is the median stone size in feet. This relationship, which was developed from natural streams with slopes less than 2% for uniform flow conditions over submerged riprap is shown as the solid line in Fig. 4.7. However, the Anderson et al. (1970) relationship is commonly used and extrapolated to estimate roughness on steep slopes. Anderson et al. did not consider the resistance to be a function of slope.

The U.S. Army Corps of Engineers (COE, 1970) have also developed a procedure for estimating Manning's n value. Althrough the COE procedure was formulated for flat slopes and deep flow depths (1-60 ft), it is routinely applied to estimate flow resistance of steep slopes. The Manning's n is calculated as

$$n = \frac{R^{1/6}}{23.85 + 21.95 \log_{10} (R/K)} \qquad (4.10)$$

where R is the hydraulic radius and K is the equivalent roughness height in ft. The equivalent roughness for stone lined channels is the theoretical spherical diameter of the median stone size. The hydraulic radius is approximated with the depth of flow in wide channels.

The CSU and Anderson et al. (1970) equations were compared to demonstrate the effect that slope has on the Manning's n. The Manning's n values were approximated by applying Eq. 4.8 and Eq. 4.9 for median stone sizes of 2.2 inches and 5.1 inches on slopes of 1%, 2%, 5%, 10% and 20%.

The results of the analysis (Table 4.9) indicate that at slopes below 2%, the Anderson et al. equation yields slightly greater n values (approximately 10%) than does the CSU equation. The CSU and Anderson et al. relations coincide at a slope between 2% and 5%.

The CSU and Anderson et al. relations yield significantly different Manning's n values at steep slopes ($\geq$10%). The Anderson et al. n value remains constant at 0.034 for a 5.1-inch stone (D_{50}) for all slopes. However, the CSU equation yields an n value of 0.046 for a 5.1-inch stone (D_{50}) at 20% slope, a value 35% greater than predicted by Anderson et al. It is evident that the Anderson et al. formulation can lead to erroneous designs if applied to slopes greater than 2%.

An attempt was also made to compare the Manning's n value from the U.S. Army Corps of Engineers procedure (COE, 1970) with the CSU results presented in Fig. 4.8. As observed in Table 4.9, the COE n values are less than the Anderson et al. and CSU values at slopes less than 10%. However, the COE value meets or exceeds the Anderson et al. and CSU n values for slopes of 10% or greater.

It should be noted that the CSU equation was based on computed average n values and does not indicate the upper range of localized n values which extended from 0.06 to 0.08. Appendix C, Summary of Hydraulic Data, presents the localized n values resulting from each test of the testing program.

4.3.3 Bed Critical Shields' Coefficient

The bed critical Shields' coefficient, C_C, was computed for each test as presented in Table 4.6 and Table 4.7. The Shields' coefficient of each

Reference: Use of Riprap for Bank Protection
Hydraulic Engineering Circular No. 11
US DOT Federal Highway Admn 1978

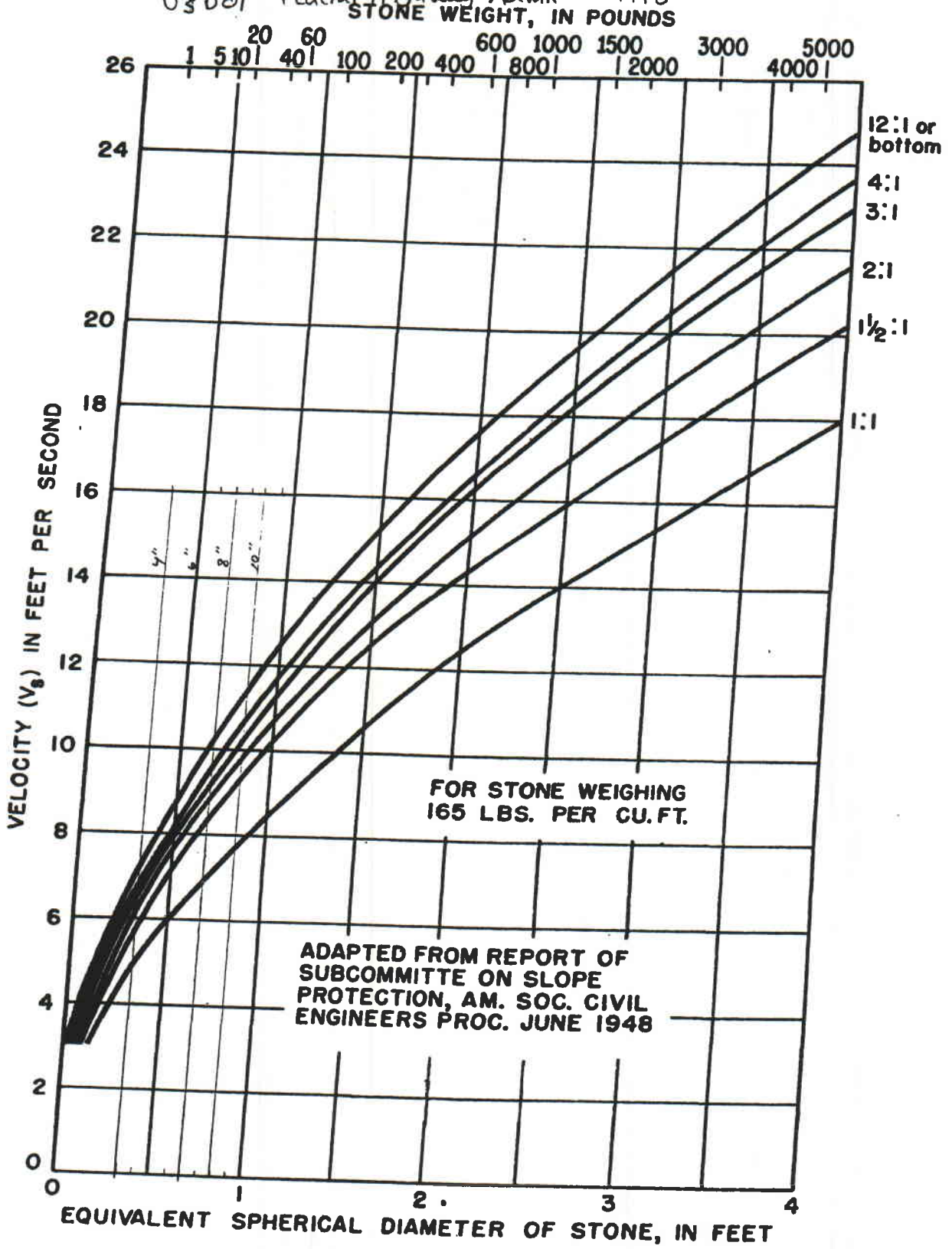

FIG. 2 - SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

Reference: Design Hydrology and Sedimentology for Small

Table 4.13 Calculations for Example Problem 4.19

D_{50}[a]	Manning's n	Depth to convey flow (ft)	Maximum tractive force on channel bed (lb/ft^2)	Channel bed stability factor (η_b)	Safety factor for channel bed (SF_b)	Maximum tractive force on walls (lb/ft^2)	Channel wall stability factor (η')	Chann wall safety factor (SF)
1.7	0.043	0.72	4.49	0.541	1.53	3.41	0.308	1.36
2.0	0.044	0.73	4.58	0.467	1.72	3.48	0.268	1.45
2.5	0.046	0.75	4.68	0.382	2.02	3.56	0.220	1.56
2.2	0.045	0.74	4.62	0.429	1.84	3.51	0.247	1.50

[a]Use a riprap with a D_{50} of 2.2 ft for both channel sides and bottom.

From Eq. (4.46),

$$\beta = \tan^{-1}\left[\frac{\cos\lambda}{2\sin\alpha/\eta\tan\phi + \sin\lambda}\right]$$

$$= \tan^{-1}\left[\frac{\cos(5.71)}{2\sin(21.8)/(0.408\tan(42)) + \sin(5.71)}\right].$$

$$\beta = 25.1°$$

From Eq. (4.48),

$$\eta' = \eta\left[\frac{1+\sin(\lambda+\beta)}{2}\right] = 0.408\left[\frac{1+\sin(5.71+25.10)}{2}\right]$$

$$\eta' = 0.308.$$

From Eq. (4.45),

$$SF = \frac{\cos\alpha\tan\phi}{\eta'\tan\phi + \sin\alpha\cos\beta}$$

$$= \frac{\cos(21.8)\tan(42)}{0.308(\tan(42)) + \sin(21.8)\cos(25.1)}$$

$$SF = 1.36.$$

Thus the riprap is stable, but does not have the required safety factor of 1.5. The selection of an acceptable riprap for the channel side slopes will be made using trial and error. The calculations are in Table 4.13. It is assumed that the riprap on the channel bed will be the same as that used on the side slopes. It would obviously be possible to vary the side slopes and channel width to obtain a smaller D_{50}. The final selection of channel dimensions and riprap size would have to be based on economics.

Selecting Proper Gradation

It is important for a riprap to have a gradation such that the voids between the larger particles are filled with smaller particles to reduce flow beneath the riprap and the formation of open pockets. A suggested gradation for riprap has been made by Simons and Senturk (1977, 1992) based on studies at Colorado State University. The proposed gradation is shown in Fig. 4.19.

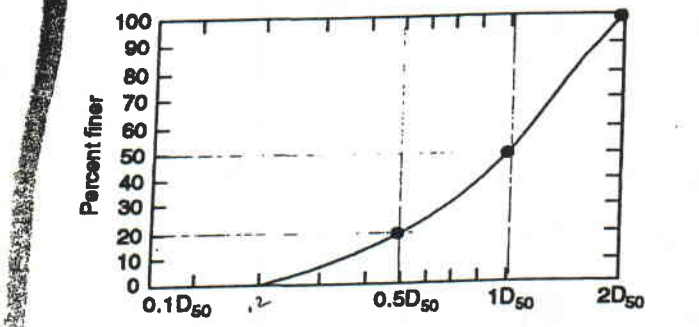

Figure 4.19 Suggested size distribution of riprap (after Simons and Senturk, 1977, 1992).

Selecting an Underlying Filter

The placement of a properly designed filter blanket underneath the riprap is necessary when the particle size of the riprap is much larger than that of the base material. The following criteria have been established for sizing the filter, based on the size distribution of the riprap and the base material:

(1) $$\frac{D_{50}(\text{filter})}{D_{50}(\text{base})} < 40 \quad \text{also} \quad \frac{D_{50}(\text{riprap})}{D_{50}(\text{filter})} < 40$$

(2)
$$5 < \frac{D_{15}(\text{filter})}{D_{15}(\text{base})} < 40 \quad \text{also} \quad 5 < \frac{D_{15}(\text{riprap})}{D_{15}(\text{filter})} < 40$$

(3) $$\frac{D_{15}(\text{filter})}{D_{85}(\text{base})} < 5 \quad \text{also} \quad \frac{D_{15}(\text{riprap})}{D_{85}(\text{filter})} < 5.$$

These criteria were developed for sizing filters around drain pipe to prevent piping of the soil into the